ENVIRONMENTAL RESOURCES VALUATION IN ENVIRONMENTAL IMPACT ASSESSMENT: TOWARDS AN EFFICIENT VALUATION SYSTEM

Marcelo Sequeira Marques

Dissertação para a obtenção do Grau de Mestre em

Engenharia do Ambiente

Orientador: Doutor António Guerreiro de Brito

Coorientador: Doutor José Manuel de Lima e Santos

Júri:

Presidente:

Doutor Francisco Ramos Lopes Gomes da Silva, Professor Auxiliar do(a) Instituto Superior de Agronomia da Universidade de Lisboa

Vogais:

Doutora Maria Teresa Marques Ferreira, Professora Catedrática do(a) Instituto Superior de Agronomia da Universidade de Lisboa

Doutor José Manuel Osório de Barros de Lima e Santos, Professor Catedrático do(a) Instituto Superior de Agronomia da Universidade de Lisboa

Lisbon, 2017

ACKNOWLEDGEMENTS

I would like to thank…

…my dissertation advisor Professor António José Guerreiro de Brito for its constant availability and support in every issue that emerged during this dissertation;

…my dissertation co-advisor Professor José Manuel Osório de Barros de Lima e Santos for its guidance and clarification of doubts;

…my course professors, for all their transmitted knowledge, effort, and dedication;

…my family, for the unconditional support during the accomplishment of this dream;

…my girlfriend, Sandra, for all her support and patient, particularly during the times of greatest frustration;

…the ones that have contributed in any way but were not referred here.

RESUMO

Cada membro da União Europeia realiza análises a certos projetos capazes de provocar impactes no ambiente através do instrumento de Avaliação de Impacte Ambiental.

O conteúdo dessa avaliação verificada nos documentos correspondentes à Avaliação de Impacte Ambiental, especificamente no Estudo de Impacte Ambiental, aparente ser algo subjetiva, sendo que a descrição dos recursos ambientais afetados pela implementação do projeto sob os procedimentos é apresentada com um certo nível de abstração. Este trabalho procura apresentar formas de melhorar a objetividade e consequentemente a clareza dessas Avaliações de Impacte Ambientais, focando-se principalmente em demonstrar a valoração de recursos ambientais afetados pelo projeto de Avaliação de Impacte Ambiental, permitindo uma melhor compreensão por parte dos tomadores de decisão relativamente ao valor real dos recursos pré-existentes na área do projeto.

A grande problemática diretamente relacionada com a valoração de recursos está centrada na fácil atribuição de valores monetários sempre que esses recursos tenham um preço de mercado, em contra posição aos restantes recursos sem preço de mercado. Esta abordagem envolve a adoção de um sistema de classificação de bens e serviços de ecossistemas, particularmente para este caso, o Common International Classification of Ecosystem Services que abrange os recursos ambientais considerados na Avaliação de Impacte Ambiental.

The great problematic directly linked to the resources valuation is centred in the easy monetary value attribution whenever a resources has a market price counter pointing the remaining non-marketed resources. Such approach involves the adoption of a classification system of ecosystem goods and services, particularly in this case the *Common International Classification of Ecosystem Services* that comprises the environmental resources considered in the Environmental Impact Assessments.

Finalmente a aplicação da abordagem *Common International Classification of Ecosystem Services* integrada na Avaliação de Impacte Ambiental é demonstrada e é realizada a valoração de recursos ambientais através do método de transferência de benefício, servindo de exemplo para a potencialidade deste procedimento.

Keywords: Ecosystem Services; Environmental Impact Assessment; Valuation; Common International Classification of Ecosystem Services.

ABSTRACT

Each European Union state member performs analysis on certain projects possible impacts on the environment through the instrument of Environmental Impact Assessment. This procedure has been implemented on each member state level, being altered and improved e several occasions, finding itself under constant evolution.

The content of that assessment verified in the correspondent documents of the EIA, specifically in the Environmental Impact Statement, appear to be somewhat subjective, being that the description of the affected environmental resources by the project implementation under that procedure is presented with a certain level of abstraction. This work looks forward to present ways to enhance the objectivity and consequently the clearness of those Environmental Impact Assessments, focusing mainly on demonstrate the valuation the environmental resources affected by the Environmental Impact Assessment project, allowing a better comprehension by the stakeholders about the real value of the pre-existent resources in the area of the project.

The great problematic directly linked to the resources valuation is centred in the easy monetary value attribution whenever a resources has a market price counter pointing the remaining non-marketed resources. Such approach involves the adoption of a classification system of ecosystem goods and services, particularly in this case the Common International Classification of Ecosystem Services that comprises the environmental resources considered in the Environmental Impact Assessments.

Finally the application of the Common International Classification of Ecosystem Services approach integrated in the Environmental Impact Assessment is demonstrated and the valuation of the environmental resources is performed through the benefit transfer method serving as example for the potentiality of this procedure.

Keywords: Ecosystem Services; Environmental Impact Assessment; Valuation; Common International Classification of Ecosystem Services.

RESUMO ALARGADO

Atualmente a União Europeia defende uma política para um desenvolvimento sustentável para com o Ambiente, sendo que cada estado membro da União Europeia, realiza análises a possíveis impactes que certos projetos possam provocar no meio ambiente sob a forma de Estudos de Impacte Ambientais. Este procedimento que tem sido implementado sob a forma de Diretivas a nível de cada estado membro tem sido alterado e melhorado em certas ocasiões encontrando-se em constante evolução. A avaliação desses Estudos de Impacte Ambiental aparenta ser algo subjetiva, sendo que a descrição dos recursos ambientais afetados pelo projeto sujeito a esse procedimento apresenta-se com algum nível de abstração. Este trabalho procura propor formas de aumentar a objetividade e portanto a clareza desses mesmos Estudos de Impacte Ambientais, e sabendo que a valoração de recursos ambientais tem sido aplicada com êxito na determinação de impactes de desastres ecológicos no ambiente, é sugerida a introdução deste tema em projetos de Estudo de Impacte Ambiental.

O principal objetivo deste trabalho foca-se em demonstrar a possibilidade de uma aplicação prática da valoração de recursos ambientais nos processos atuais, e futuros de Avaliações de Impacte Ambientais de diferentes áreas de intervenção dentro dos estados membros, com particular destaque para Portugal. De modo a permitir que exista uma melhor compreensão por parte das partes interessadas sobre o verdadeiro valor dos recursos pré existentes na área do projeto de EIA, este trabalho explora um conjunto de metodologias para implementar essa prática.

Primeiramente são identificados os principais métodos de valoração de recursos ambientais de forma a compreender como estes podem ser utilizados em projetos sujeitos a Estudos de Impacte Ambientais. A abordagem adotada neste trabalho considera os recursos ambientais como capital natural onde através dos bens e serviços de ecossistemas, os seus benefícios podem ser aproveitados pelos seres humanos. São então apresentados os principais métodos de valoração passíveis de ser aplicados a serviços e bens de ecossistemas, começando pelos principais tipos de valores considerados, nomeadamente o valor de uso, o valor de opção e o valor de não uso (valor passivo), e as suas categorias, nomeadamente os métodos diretos e indiretos do uso do recurso, de preferência revelada ou declarada. O maior destaque é dado para o método de transferência de benefícios que devido à sua capacidade de transferir informação de outros estudos já realizados, permite economizar os custos e poupar tempo aos tomadores de decisão. Este é pois o método preferível por estes e também o método adotado por este trabalho para a valoração de recursos ambientais.

A grande problemática diretamente ligada à valoração dos recursos ambientais está centrada na facilidade de atribuir valores monetários quando os recursos têm um preço de mercado em contraposição aos restantes recursos que não têm preço de mercado. Uma valoração sistemática destes bens e serviços de ecossistemas exige haver um ponto de referência de classificação destes, e tal abordagem passa pela adoção de estruturas de trabalho de avaliação de bens e serviços de ecossistema, sendo analisadas as tendências relativas à classificação destes dentro da União Europeia. Esta é então a solução encontrada para conjugar os dois temas principais deste trabalho, nomeadamente os Estudos de Impacte Ambientais e a valoração de recursos ambientais, mas para o fazer tem de se compreender quais os sistemas de classificação de bens e serviços de ecossistemas mais utilizados dentro da União Europeia. Tendo evidências de que atualmente entre os estados membros da União Europeia é utilizado com maior frequência o sistema de classificação de bens e serviços de ecossistemas *Common International Classification of Ecosystem Services*, para melhor compreender o porquê desta opção e quais os antecessores deste sistema. É então descrito e analisado, o primeiro e mais internacionalmente reconhecido sistema de classificação de bens e serviços de ecossistemas, o *Millennium Ecosystem Assessment*, sobre o qual se baseia a maior parte da bibliografia atual sobre os estudos relativos dos bens e serviços de ecossistemas e respetiva valoração. O segundo sistema de classificação de bens e serviços de ecossistemas a considerar, e baseado no modelo referido anteriormente, é o *The Economics of Ecosystems and Biodiversity* do qual o modelo adotado por este trabalho é baseado. Sendo apresentadas as várias propriedades de cada um destes sistemas, são compreendidos os fundamentos e atuais causas para a inclusão do sistema *Common International Classification of Ecosystem Services* em vários instrumentos de políticas de avaliação de ecossistemas de vários estados membros da União Europeia. São compreendidos também os pontos fortes e fracos deste sistema adotado, bem como as limitações desta abordagem em Estudos de Impacte Ambientais, com foco na exclusão de alguns potenciais impactes provocados por projetos sobre a população que não são abrangidos pelos bens e serviços de ecossistema.

Nos resultados deste trabalho são analisados catorze projetos de Avaliações de Impactes Ambientais portugueses de diferentes categorias de acordo com a legislação atualmente em vigor em Portugal para este tipo de projetos, representando a maior variedade possível de categorias considerando os documentos disponíveis aquando da realização deste trabalho.

Numa primeira fase após a análise à existência de um sistema de classificação de bens e serviços de ecossistemas conjugado com alguns dos métodos de valoração aqui referidos em qualquer dos casos de Estudos de Impacte Ambiental obter um resultado negativo. De seguida e com o mesmo resultado, é feita análise destes dois componentes em separado, optando-se então por identificar elementos da amostra dos projetos de Estudo de Impacte Ambiental que possam integrar o sistema classificação *Common International Classification of Ecosystem Services.*

Numa segunda fase, tendo destacado e classificado todos os bens e serviços de ecossistemas mencionados na amostra de casos de estudo procede-se a uma valoração dos recursos ambientais que abranja vários desses casos de estudo através do método de transferência de benefícios para exemplificar a potencialidade deste procedimento. Neste procedimento recorre-se a um caso de estudo de valoração de bens e serviços de ecossistemas que recorre à meta-análise, a abordagem mais robusta do método de transferência de benefícios aqui preferenciada, possibilitando abranger neste caso específico, à valoração de um serviço de ecossistema em vários casos de estudos de Avaliação de Impacte Ambiental aqui analisados, obviamente com as devidas adaptações. Sendo apresentados os valores monetários relativos a três desses casos referentes aos serviços de ecossistema de uso físico de panoramas terrestres ou marítimos em diferentes cenários ambientais. Correspondendo estes valores à área de implementação do projeto principal do devido caso de estudo de Avaliação de Impacte Ambiental, na ausência deste. Esses valores obtidos representam então o valor monetário para o uso físico de panoramas terrestres, correspondente à realização de atividades como caminhadas e caça desportiva em áreas de florestas europeias correspondentes à região geográfica Mediterrânica, à qual pertence a totalidade da amostra de projetos de Avaliação de Impacte Ambiental presentes neste trabalho.

Com estes resultados é demonstrada a possibilidade de aplicação do conceito aqui estudado de implementação de valoração de recursos ambientais em Estudos de Impacte Ambientais via sistemas de classificação de bens e serviços de ecossistemas, com as devidas vantagens e limitações.

Concluindo por estes resultados, que a implementação da abordagem aqui proposta de integração da valoração dos recursos ambientais em Estudos de Impacte Ambientais via adoção de um sistema de classificação de bens e serviços de ecossistema enfrenta não só os fatores limitadores da sua implementação, mas herda também os principais desafios à adoção de um sistema de classificação de bens e serviços de ecossistemas comum entre os estados membros da União Europeia.

Palavras-chave: Serviços de ecossistemas; Estudo de Impacte Ambiental, Valoração; Common International Classification of Ecosystem Services, Millennium Ecossistem Assessment, The Economics of Ecosystems and Biodiversity.

INDEX

TABLE LIST

FIGURE LIST

ABBREVIATIONS LIST

APA – *Agência Portuguesa do Ambiente* (Portugal Environmental Agency)

CCDR – *Comissão de Coordenação e Desenvolvimento Regional* (Coordinative and Development Regional Commission)

CESVS – Chosen Ecosystem Services Valuation Study

CICES – Common International Classification of Ecosystem Services

DEFRA – Department for Environment, Food and Rural Affairs

EIA – Environmental Impact Assessment

EU – European Union

ES – Ecosystem Goods and Services

IPCC – Intergovernmental Panel on Climate Change

MEA – Millennium Ecosystem Assessment

TEEB – The Economics of Ecosystems and Biodiversity

TEV – Total Economic Value

WTP – Willingness To Pay

1. INTRODUCTION AND OBJECTIVES

1.1. Introduction

Portugal as a European Union (EU) member state has the commitment to guarantee a sustainable development by performing assessment on public and private projects capable of producing significant effects on the environment, ranging from both national to cross-border scale (1985). As any other member state of the EU this assessment is performed under the Environmental Impact Assessment (EIA), a set of normative procedures composed by a number of documents subjected to both EU and nationally specific criteria by the EIA directive and the specific national legislation respectively (2013). From the assessment on those projects, results an analysis on the risks that may be inflicted to the environment with a certain level of scope flexibility. The content of that assessment verified in the correspondent documents of the EIA appear to be somewhat subjective, being that the description of the affected environmental resources by the project implementation under that procedure is presented with a certain level of abstraction. Considering the environmental resources valuation already proved to be effective in the determination of real impacts of ecological disasters in the environment (Tietenberg and Lewis, 2011), its inclusion on EIA procedures may be a step for a more accurate analysis on a projects' the real environmental risks.

1.2. Objectives

1.2.1. General Objective

This work focuses on demonstrate the practical application of the Environmental Resources Valuation in EIA projects from distinct intervention areas between EU state members, addressing specifically to Portugal.

1.2.2. Specific Objectives

The specific objectives of this work are:

- To analyse the existent environmental resources valuation methods;
- To determine the current state of the EIA projects in Portugal regarding the environmental resources valuation;
- To propose an environmental resources valuation application methodology in EIA projects.

1.3. Dissertation Structure

This work is divided into three main chapters:

First Chapter: The State-of-Art is where the concept and applicability of the EIA on European and Portuguese level is demonstrated followed by the identification and description of the current available environmental resources valuation methodologies. Finally the bridge between these two themes is established by the introduction of the Ecosystem Services (ES) conceptual and categorizing frameworks that are intrinsically connected to the Environmental Resource Valuation methods.

Second Chapter: The sample collection and criteria methodology are specified and its analysis results are presented followed by the possible application of the given ES classification system alongside with valuation methods are performed for the selected EIA reports.

Third Chapter: The last component provides a reflection over the advantages and limitations over this approach focusing on the reliability of an integrated ES valuation framework on EIA projects in Portugal and other European state members.

2. STATE-OF-ART

2.1. General framework

The concept of valuating the ES in the EIA projects is not new, although it's giving its first steps towards its reliable practical application. To fully understand the entire panorama, one must acknowledge which are the organizations that promote that kind of valuation, and thus identify the already available methodologies. Prioritizing the most widely recognized and advanced ES valuation frameworks on this field of action and taking advantage of the available data in form of databases or scientific documents, the possible application in real case studies should be possible. The understanding of spatial and temporal trade-offs between humans and ecosystems could be improved by the recognition of the ES at all levels of management purposes by the decision makers (Honrado et al., 2013).

2.2. Legal framework

The EU EIA directive, implemented since 1985, namely the Directive 85/337/CEE is applied on a wide group of public and private project on several member countries (1985). Each member has the responsibility to decide on which situations the EIA must be applied on, through the screening process that determines its application on projects, based on the criteria of threshold or each case analysis (1985).

This directive was changed three times in 1997, 2003 and 2009 accordingly. In 1997 (Directive 97/11/CE) the UN ECE Espoo Convention standards were introduced under the transboundary context, augmenting the group of the EIA projects applicable list (1997) .

In the year 2003 (Directive 2003/35/CE) the document was aligned with the Aarhus Convention regarding the public participation in decision making and justice access to environmental matters (2003). In its last change, in 2009 (Directive 2009/31/CE) the present list on this document, commenced/started to involve transportation, capture and storage of carbon dioxide (CO_2) projects (2009). Later in 2011 the Directive 2011/92/EU has codified the initial Directive 85/337/CEE, and its three amendments, being then amended by the Directive 2014/52/EU back on 2014 (2014).

Finally the Portuguese legislation in resemblance with other EU Member States has transcribed the Directive 2011/92/EU (the initial document, not amended) into force until

2014, to its "national legislation" under the Statutory Law D*ecreto-Lei n. º 151-B/2013, de 31 de outubro*. Following the Directive 2011/92/EU first amendment, the *Decreto-Lei n. º 151-B/2013* is amended by the *Decreto-Lei n. º 47/2014*, and then amended once more by the *Decreto-Lei n. º 179/2015*.

The relationship between the EU EIA Directives and the Portuguese EIA statutory laws into force are summarized in Fig. 1.

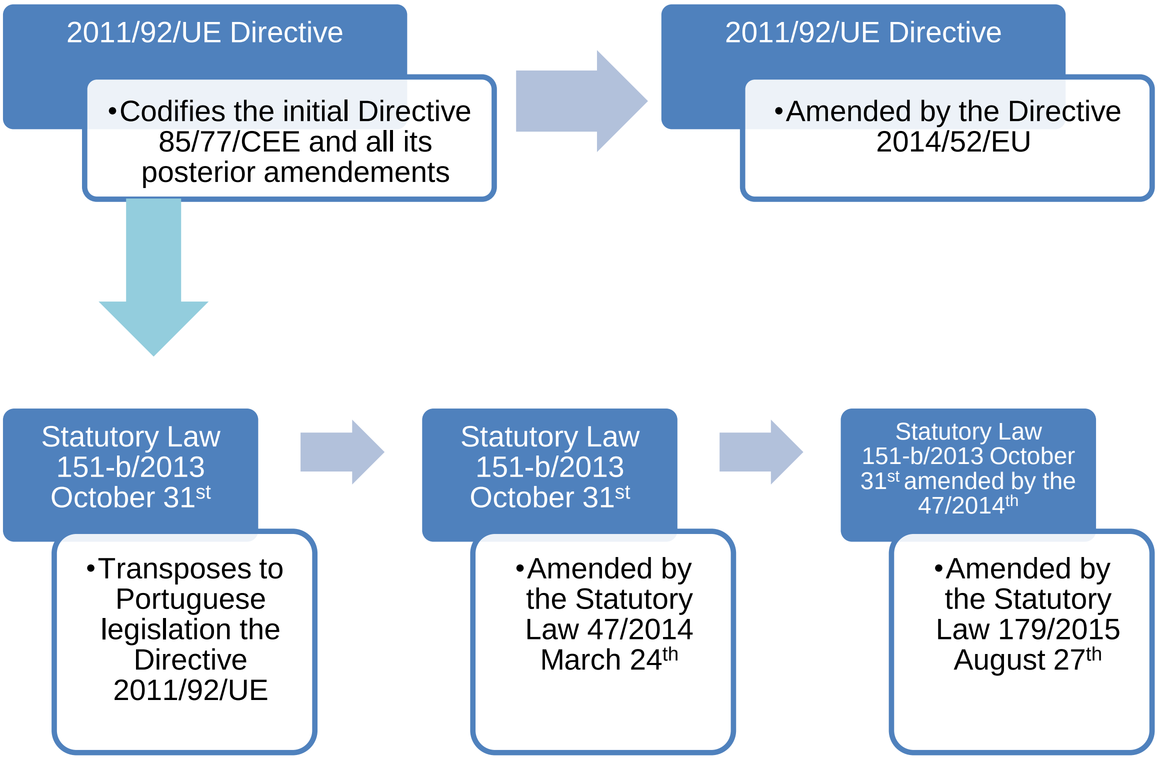

Fig. 1 - Relationship between the European Union Environmental Impact Assessment Directive and the correspondent Portuguese statutory law

At national level, there are two EIA authorities, the main one, the Portugal Environmental Agency, namely *Agência Portuguesa do Ambiente, I.P.* (APA), and the Coordinative and Development Regional Commission, namely *Comissão de Coordenação e Desenvolvimento Regional* (CCDR) of each one of the five Portuguese regions (*Norte, Centro, Lisboa e Vale do Tejo, Alentejo e Algarve*). The EIA subjected group of projects under the APA authority are found under the 8th article of the Statutory Law *Decreto-Lei n.º 151-B/2013*, where it lies stated in the very same article that any other project not included in that group, will be under the CCDR authority of its regional centre (2013). APA stands for a public institute integrated in the indirect State administration, under the Ministry of the Environment (*Ministério do Ambiente*) role with administrative and financial autonomy and self-patrimony, resulting from the fusion of nine different organisms by the statutory law *Decreto-Lei n.º 56/2012, de 12 de março (2012).*

2.3. Environmental Impact Statement

2.3.1. Definition

The EIA is a protective environmental tool of political character, sustained by accomplishment of studies and queries, with public participation and possible alternative analysis, aiming to identify, gather information, and predict environmental effects of certain projects as well as identification of preventive, minimizing or avoidance measures for its effects, aiming for an effective decision about the projects viability and post-evaluation (1985). By measuring these environmental impacts, it assess the set of favourable or unfavourable changes in the environment on certain factors, on a given time period in a given area, resulting from the realization of a project in comparison with what would occur in its absence on the same time period and area (2013).

2.3.2. Importance

The EIA is the most widespread form of Impact Assessment, providing the decision makers with information about the possible significant direct and indirect environmental impacts of ongoing projects and its alternatives, supported by the definition of measures to avoid, minimize or compensate those impacts (Honrado et al., 2013). Thus the project effects must be monitored in order to assure the efficiency of the defined measures for that project.

The transparency of the decision making of a project is safeguarded by its public review and participation, through the dialog and the consensus about administration function performance (2012).

2.4. Environmental Resources Valuation

2.4.1. Methods

Valuation consists in appointing a monetary value (Damigos et al., 2016) involving the assessment of the trade-offs toward achieving a goal (Costanza et al., 2014; Farber et al., 2002). In order to do so one must consider the sustainable human well-being (Costanza et al., 1997; Costanza et al., 2014; Damigos et al., 2016; Millennium Ecosystem Assessment, 2005) which results from the interaction between the built, the social, the human and the natural capital, where this interaction is required for the benefits from the natural capital to flow into the human well-being as summarized in Fig. 2 (Costanza et al., 2014).

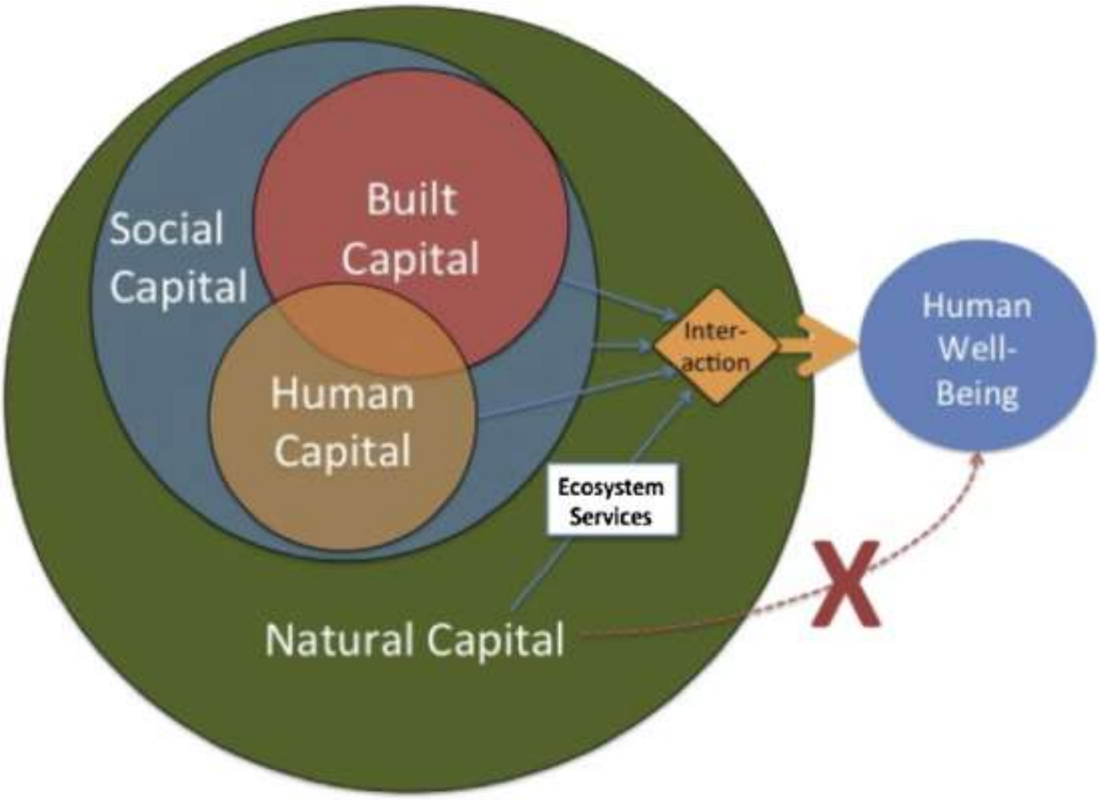

Fig. 2 - Interaction between built, social, human and natural capital required to produce human well-being

That natural capital consists in the earth's limited natural resources stocks, both physical and biological from which the ES' flow of material, energy and information (defined in Table 1 and correlated and contextualized in Fig. 3) are provided, contributing ultimately for the human welfare (Costanza et al., 2014; Jónsson and Davíðsdóttir, 2016; The Economics of Ecosystems and Biodiversity, 2010; Tietenberg and Lewis, 2011; Turner et al., 2016).

Table 1 - Definition of ecosystem services

Ecosystem Services
Benefits that humans populations derive, directly or indirectly from ecosystem functions such as the habitat, biological or system properties or processes of ecosystems (Costanza et al., 1997; Ding et al., 2016). Ecosystem goods alongside with ES or also referred all together as ES (Costanza et al., 1997; Raffaelli, 2010) as well in the rest of this document, represent the benefits

human populations derive, directly or indirectly from ecosystem functions (Costanza et al., 1997; Department for Environment Food and Rural Affairs, 2007; Ding et al., 2016)

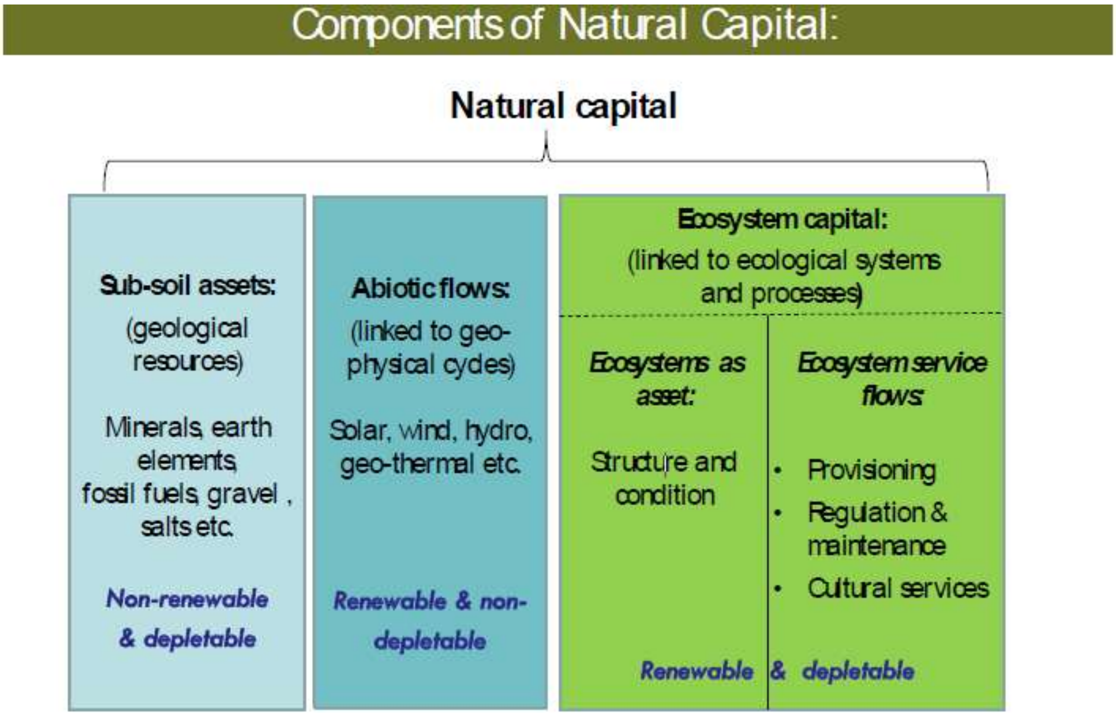

Fig. 3 – The main components of natural capital divided in ecosystem capital as combination of biotic and abiotic factors; non-renewable abiotic assets such as fossil fuels; and non-depletable abiotic resources such wind and solar energy from *Mapping and Assessment of Ecosystems and their Services* (European Comission, 2013)

The ES allow the society to evaluate and estimate the social and economic impacts of changes in resource availability (Beaumont et al., 2007; Lemasson et al., 2017). Moreover it establishes the connection between the ecosystem health and human use, providing the decision makers with information to a sustainable use and protection of the ecosystems (Lemasson et al., 2017). Thus the quality and availability of an environment asset or flow will have its influence on the human well-being, which in turn in an economic point of view, any change on this condition is measured in monetary values and based on the Total Economic Value (TEV) of that asset (Damigos et al., 2016). The TEV of an asset constitutes a complex trade-off system which can be desecrated into three main components for a better understanding all of which based on preference approach: use value, option value, and non-use value respectively (Koundouri et al., 2016; Tietenberg and Lewis, 2011).

Types of values / valuation techniques

Use value - This value could be of direct use of the environmental resource (Tietenberg and Lewis, 2011) such as an environmental good or service for commercial purposes or recreation, where one experience that resource with, at least, one of the human senses (Costanza et al., 2014). Also the use value includes the indirect use which can be called passive-use or non-consumptive use, where in the process of experiencing a resource, one does not really use it (consumes it) such as benefiting from ES and functions without directly using them (Costanza et al., 2014; Tietenberg and Lewis, 2011).

Option value - It represents the ability of use a resource in the future as an insurance premium (Damigos, 2006; Damigos et al., 2016; Tietenberg and Lewis, 2011). This resource is not being used at the present but it has a potential possible future use which can be obtained through its preservation that will depend on the monetary amount estimation that the one is prepared to pay to do so, namely its Willingness To Pay (WTP) (TEEB, 2010; Tietenberg and Lewis, 2011).

No use value – Also referred to as “passive use” values, stands for a resource that will never be used by one that can be improved or preserved depending on the WTP, it may be divided in three different categories: the altruistic value, the bequest value and the existence value (Damigos et al., 2016; DEFRA, 2007; Tietenberg and Lewis, 2011). The bequest value consists on ensure that people will provide their heirs to have a natural resource available from them to use in the future (Damigos et al., 2016; Tietenberg and Lewis, 2011). Finally the existing value is measured by the WTP to guarantee the resource existence without any current or future interests in using it, driven by moral reasons (Damigos et al., 2016; DEFRA, 2007; Tietenberg and Lewis, 2011).

The three main environmental resources value types from the TEV can be summarized in Table 2:

Table 2 - The three main environmental resources value types (Tietenberg and Lewis, 2011)

Category	Description
Use Value	Environmental resource direct use
Option Value	WTP to ensure the future environmental resource usage option even when it is not being used in the present time
Non-use Value (passive value)	WTP for an environmental resource which will not be used by one, but it can be improved or preserved to another

Valuation methods classification

Typically, the researcher's goal is to estimate the total WTP for the good or service in question (Tietenberg and Lewis, 2011). However, nonmarket goods and services, require the estimation of WTP either through examining behaviour, drawing inferences from the demand for related goods, or through responses to surveys.

Stated preference

Stated preferences approaches may be used when the value of the environmental and/or social good or service is not directly observable, where by means of survey techniques, the individuals' WTP for a change in the quantity or quality of those environmental goods and services (Chee, 2004; Damigos et al., 2016; Pérez-Blanco et al., 2016; TEEB, 2010; Tietenberg and Lewis, 2011). Referred as the main type of stated preference technique, the contingent valuation is the most direct, and mostly worldwide used approach (Carson, 2004) (Damigos et al., 2016), provides a means of deriving values that cannot be obtained in more traditional ways (Tietenberg and Lewis, 2011). This survey approach creates a hypothetical market and asks a sample of individuals to state their hypothetical maximum WTP for an environmental improvement or their minimum WTA to avoid a certain deterioration of it (Damigos et al., 2016; Saarikoski et al., 2016; Tietenberg and Lewis, 2011).

Contingent valuation

It's the most direct approach of the stated preference methods (Tietenberg and Lewis, 2011), survey-based, that creates a hypothetical market via a questionnaire, and measures the one's WTP for an environmental change or to preserve the resource in its current state on the existence of this market (DEFRA, 2007; Tietenberg and Lewis, 2011).

A robust method that allows to capture all components of the TEV (DEFRA, 2007), from the individual to the aggregated ones (Cook et al., 2016). One of its features is the valuable application potential on cases where limited or no observed behaviour exists to estimate the TEV of an environmental resource or its specific ES through other methods (Cook et al., 2016).

This method has been widely adopted (Cook et al., 2016), although in practice it may be very difficult to assess many different use and non-use values (DEFRA, 2007) where potentially poorly conceived surveys due to ill-informed surveyed individuals or other factors that could make those to give biased answers, representing this methodology major flaw (Cook et al., 2016; Costanza et al., 1997; Tietenberg and Lewis, 2011).

Revealed preference

This methodology allows the benefits of non-marketed goods and services to be estimated based on actual observable choices from which those are directly inferred involving actual consumer behaviour (Damigos et al., 2016; Saarikoski et al., 2016; Tietenberg and Lewis, 2011).

Travel Cost Method

This is a survey-based technique which infer the value of a recreational resource through the information about the how much the visitors spent to get to the site (DEFRA, 2007; Tietenberg and Lewis, 2011).

Analysts examine the number of trips visitors make to a site, creating a travel cost demand function where the use value can be captured whereas the visitor’s non-use values cannot be assessed by this method (DEFRA, 2007; Tietenberg and Lewis, 2011).

There has been practical applications of this methodology to value beach closures during oil spills, fish consumption advisories, and the cost of development that has eliminated a recreation area (Tietenberg and Lewis, 2011).

Random Utility Model

Considered to be and extension of the travel cost method (DEFRA, 2007), it captures the use value of the ones choice on a particular site, including its characteristics (ease of access and environmental quality) and price (trip cost) (DEFRA, 2007; Tietenberg and Lewis, 2011). This assigns a unique level of utility for that site, allowing changes in welfare to be measured by the utility loss of a negative environmental impact event, as the ones choose a an alternate, less desirable place (Tietenberg and Lewis, 2011).

For the application of the Environmental Resources valuation, several different pre-existent methods must be considered which can be divided in two distant categories, revealed preference and declared preference methods. Both may be considered subdivided in direct and indirect methods, as it can be observed in Table 3:

Table 3 - Economic methods for environmental resources measuring – adapted table from Environmental & Natural Resources Economics (Tietenberg and Lewis, 2011)

Technique	Methods	
	Revealed preference	**Stated preference**
Direct	Market price	Contingent valuation
	Simulated Markets	
Indirect	Travel Cost	Attribute-Based Models
	Hedonic Property Values	Conjoint Analysis
	Hedonic Wage Values	Choice Experiments
	Avoidance Expenditures	Contingent Ranking

Benefits transfer

Benefits transfer method is a process to estimate economic values for ES by transferring available information from studies already completed in another location (study site) and/or context (policy site) (Costanza et al., 2014; de Groot et al., 2012; DEFRA, 2007; European Environment Agency, 2010; Koundouri et al., 2016; Ready and Navrud, 2006; TEEB, 2010; Tietenberg and Lewis, 2011; United Kingdom National Ecosystem Assessment, 2011). The low cost and time saving are the main factors for this methodology to be used widely by policy makers in local, national and global level of ecosystem assessments (Costanza et al., 2014; de Groot et al., 2012; DEFRA, 2007; European Environment Agency, 2010; Koundouri et al., 2016; Ready and Navrud, 2006; TEEB, 2010; Tietenberg and Lewis, 2011; United Kingdom National Ecosystem Assessment, 2011). The robustness of this methodology allows it in principle to derive values from all economic valuation approaches (DEFRA, 2007) observable in Fig. 4. Although its quick and inexpensive characteristics, the disadvantage resides in the fact that the accuracy of the estimates obtained on a given study site deteriorate as the new site temporal and spatial context deviates increases from the original ones (Tietenberg and Lewis, 2011). The value transfer method can have three forms: value transfers, benefit function transfers, or meta-analysis (Tietenberg and Lewis, 2011).

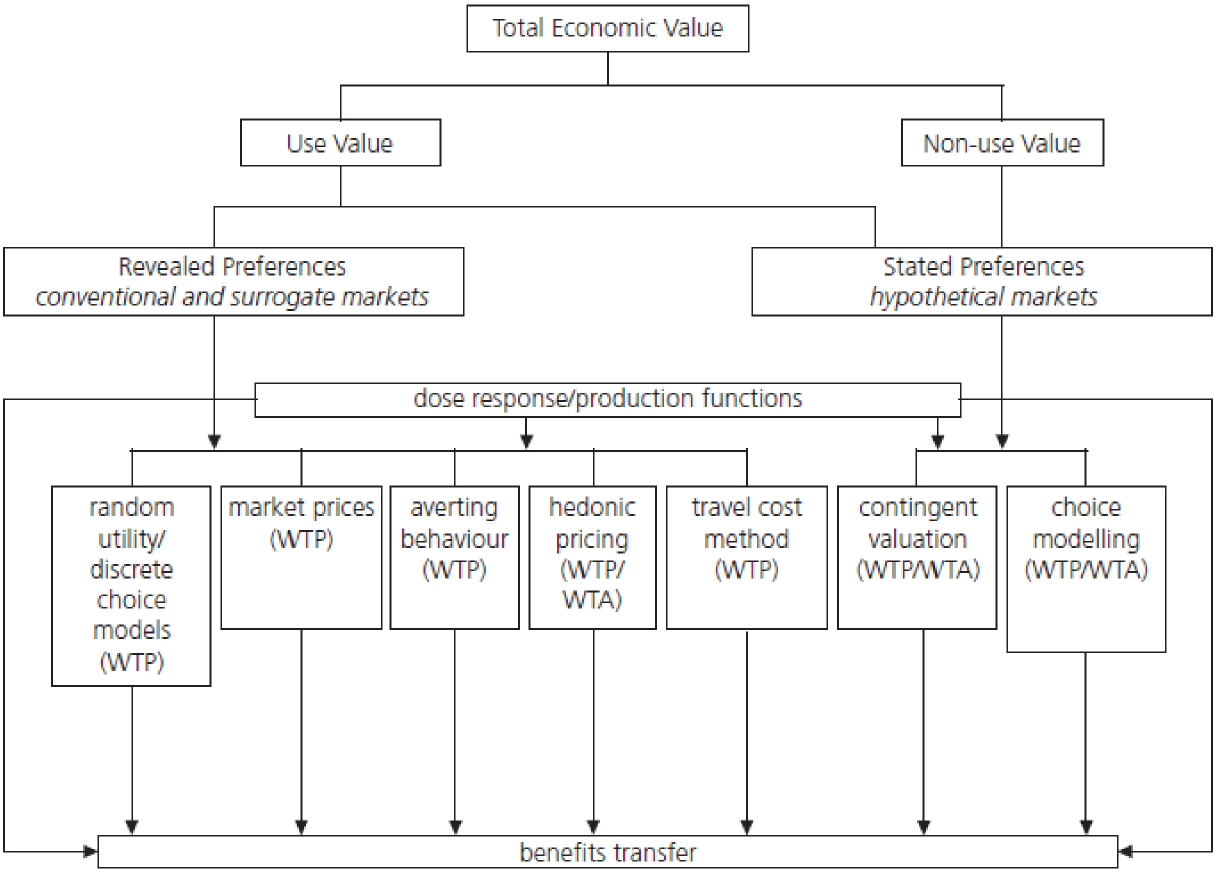

Fig. 4 - Techniques for total economic value from An introductory guide to valuing ecosystem services, Department for Environment, Food and Rural Affairs (2007) (DEFRA, 2007; Economics for the Environment Consultancy Great Britain, 1998)

2.4.2. Importance

The assignment of monetary values to ecosystem components and functions have become one of the most ES research objectives (de Groot et al., 2012; Saarikoski et al., 2016).

Within the range of known goods and services provided by the environment, only the smallest part have an explicit market for it, and thus a price on it, meaning that the market place does not account its real contribution to the social welfare, leading to externalities which in turn create market failures (Damigos et al., 2016). This externalities may be positive or negative and occur whenever the welfare of some agent, either a firm or household, depends not only on the one's activities, but also on activities under the control of some other agent, leading to a market failure to be originated (Tietenberg and Lewis, 2011). Considering the ES positive externalities as a benefit for the stakeholders and not to be a problem in this context, by the other hand the negative externalities resulting from the undervalued ES most commonly result on the over-exploitation of the resource stock (de Groot et al., 2012). To eliminate the externalities, the decision makers must be provided with specialised guides on the application of the non-marketed valuation techniques concerning the benefits from environmental resources, specifically the ES in order to prevent any net loss in social welfare of projects involving relevant environmental impacts (de Groot et al., 2012; Jónsson and Davíðsdóttir, 2016). Knowing that the provision of those ES rely upon the land use changes which are strongly influenced by environmental, socio-economic and political developments (Brunner et al., 2016; Foley et al., 2005; Rounsevell et al., 2012; Turner et al., 2007; Verburg et al., 2013), a sustainable land use management may lead to a positive scenario change benefiting the ES and ultimately the human wellbeing.

2.5. Environmental Resources Valuation in Environmental Impact Assessment

The implementation of the ES concept and typology in EIA practice is still generally and specially in Portugal quite immature, since the ES are often not explicitly considered in impact assessment on EIA studies (Honrado et al., 2013). A framework for the integration of the ES must take into account the possible components of the EIA where it can be addressed, specifically the impact assessment, monitoring and mitigation (Honrado et al., 2013). One must understand that the EIA is an assessment tool that provides quantified evidence highlighting the significance of the environmental impacts and potentially providing essential input to a cost-benefit analysis (DEFRA, 2007). Also that the EIA may integrate an ES framework and not the other way around, since the EIA is able to measure environmental impacts such as direct changes in the air quality for the health of a given population area by nitrogen emissions, or the noise effects on a given population, components that cannot be measured with differences in the ES, but by the difference between the environmental quality as it is the standard procedure of the EIA. However the valuation of ES in a large part of environmental damages highlights their value, since they contribute to the generation of income and wellbeing, and to the prevention of damages that inflicts costs on society due to the insurance, regulation and resilience functions that they provide (DEFRA, 2007). It is important to explicitly define the ES before proceeding to its valuation whether on the impact assessment of the EIA or on any other ES assessment context. Explicit mention of the problems based on factual information, enables quicker understanding by the all the actors involved, from decision makers to stakeholders, contrasting to implicit assessments where not pointed out issues will pass unnoticed (Honrado et al., 2013). Hereupon the large amount of research work on ES generated single conceptualizations and classification systems that results on different interpretation of ES and related terminology and definitions in practice (Blicharska et al., 2017; Boerema et al., 2016; La Notte et al., 2017; TEEB, 2010).

A combination of valuation techniques is often required to comprehensibly value ES (Broekx et al., 2013; DEFRA, 2007). The choice of the valuation methods will depend on the characteristics of the case, including the scale of the problem, the types of value deemed to be most relevant, data availability and the availability of human and financial resources (Broekx et al., 2013). Moreover the considered ES are usually selected based on availability of data, relevance to a study area, interests of the team conducting the assessment, or abundance of information in other ES assessments (Mascarenhas et al., 2016). Ecosystems vary widely in spatial scale and their key processes operate across a range of rates that are overlapping in time and space (UKNEA, 2011). Thus the need of consensual definitions and categories of ES is a requirement for any assessment to be recognized internationally, and the definition of a general ES assessment framework is a crucial step.

The milestone of the ES classification, at least at consensual level, resulted in the publication of the Millennium Ecosystem Assessment (MEA) (La Notte et al., 2017) by the United Nations with its protective Environmental Programme. Focusing essentially in the link between the Ecosystems and Humans, the MEA is a result of multinational conventions findings synthesised and integrated in form of reports providing the decision makers with means to a more comprehensive evaluation between the ES and the human well-being (MEA, 2005). Its objective is to “assess the consequences of ecosystem change for human well-being and to establish the scientific basis for actions needed to enhance the conservation and sustainable use of ecosystems and their contributions to human well-being” (MEA, 2005). After being called up on in 2000, it has published already two reports, the first one in 2001 and a second one in 2005 entitled “Ecosystems and Human Well-Being” (MEA, 2005). This ES framework has become widely recognized and considered a starting point as an ES categorizing method for the assessment of ES case studies (DEFRA, 2007), triggering an exponentially research on ES in scientific publications (Blicharska et al., 2017; Farhad et al., 2015; Martinez-Harms and Balvanera, 2012). Thus advances in ES assessment with a more profound understanding have been developed (Häyhä and Franzese, 2014; Liquete et al., 2013; Martín-López et al., 2014; Villa et al., 2014) simultaneously with ES mapping (Blicharska et al., 2017; Burkhard et al., 2012; Crossman et al., 2013; Kienast et al., 2009; Malinga et al., 2015), serving directly or indirectly as a reference for posterior ES frameworks and methodologies.

The base reference ES category assessment framework namely the MEA defines the four ES categories below (Adhikari and Hartemink, 2016; Blicharska et al., 2017; DEFRA, 2007; MEA, 2005; Pope et al., 2016; Quyen et al., 2017; Schwilch et al., 2016; Tietenberg and Lewis, 2011):

Provision - Products people obtain from ecosystems, such as food, fuel, fibre, fresh water (Jónsson and Davíðsdóttir, 2016; MEA, 2005; Schwilch et al., 2016).

Regulating - The benefits people obtain from the regulation of ecosystem processes, including air quality maintenance, climate regulation, erosion control, regulation of human diseases, and water purification (Jónsson and Davíðsdóttir, 2016; MEA, 2005; Schwilch et al., 2016).

Cultural – Consists in the non-material benefits that humans obtain from the ecosystems (Swetnam et al., 2016; Tenerelli et al., 2016; UKNEA, 2011) through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experiences (Blicharska et al., 2017; Jónsson and Davíðsdóttir, 2016; MEA, 2005; Schwilch et al., 2016; Ungaro et al., 2016). Besides of being directly experienced and appreciated, unlike other services, it cannot be replaced if degraded (La Rosa et al., 2016; MEA, 2005; Plieninger et al., 2013).

Its intangible and subjective dimensions makes it difficult to be quantified and integrated in the ES framework (Tenerelli et al., 2016).

Although generally the assessment of cultural services are mainly focused in the aesthetic values and are less frequently valued in comparison with the regulating, supporting and provisioning services (Fagerholm et al., 2016), there is a great financial potential associated with recreation and tourism in certain type of habitats (Everard, 2016; Sen et al., 2014). At the same time the exploitation of benefits provided by this pair of value types, can exert pressure on providing services (Everard, 2016; Halvorson and Davis, 1996).

Support - Services that are necessary for the production of all other ES, such as primary production, production of oxygen, and soil formation (Jónsson and Davíðsdóttir, 2016; MEA, 2005; Pope et al., 2016; Schwilch et al., 2016).

In the MEA framework the cultural, provisioning, and regulating services directly affect humans and its production is dependent upon the support services (Pope et al., 2016).

Built upon the outcomes of MEA (Maes et al., 2016), The Economics of Ecosystems and Biodiversity (TEEB), issues the ecosystems services, and also the biodiversity economic valuation, is an approach directed to the decision makers to be used as a tool to clarify possible flow of benefits provided with this two components, particularly the ES (Mascarenhas et al., 2016; TEEB, 2010). As a result this framework refined the distinction between services and benefits (La Notte et al., 2017), with the creation of a new cascading framework (Schwilch et al., 2016; TEEB, 2010). Hosted by the UNEP and supported by a wide range organizations including the European Commission, the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, the United Kingdom Government's Department for the Environment, Food and Rural Affairs, and Department for International Development, Norway's Ministry for Foreign Affairs, Sweden's Ministry for the Environment, The Netherlands' Ministry of Housing, Spatial Planning and the Environment and Japan's Ministry of the Environment (TEEB, 2010). Apart from a great number of reports being released by this framework, it was published in 2010 the first and unique to date volume consisting in a synthesis that highlights and illustrates the approach adopted by this framework (TEEB, 2010). TEEB also provides, through the Ecosystem Services Partnership, an "Ecosystem Services Valuation Database" available as a resource for all forms of non-commercial applications (de Groot et al., 2012). In this database the ES are estimated by multi approaches such as market prices, cost-based approaches, stated preference methods, revealed preference methods and production function approaches (de Groot et al., 2012). Although TEEB has improved some features on the already widely recognized MEA framework, there are still improvements to be made in order to achieve the objective of an effective practical ES assessment framework. In this framework, ES are grouped by three different groups opposing to four yielded by the MEA framework, differentiating on the support services that are discontinued and replaced by the new habitat services group which includes the maintenance of life cycles and the maintenance of genetic diversity (La Notte et al., 2017; TEEB, 2010).

More recently the Common International Classification of Ecosystem Services (CICES) was developed by the European Environmental Agency (Mascarenhas et al., 2016) is proposed for the integration of economic values of ES into accounting and reporting systems at EU and national level (European Comission, 2013; Haines-Young and Potschin, 2013). Its terminology is presented by the cascade model of Haines-Young and Potschin (Egli et al., 2017; Swetnam et al., 2016), linking natural systems to elements of human well-being, following a pattern similar to a production chain: from ecological structures and processes generated by ecosystems, to the services and benefits eventually derived by humans effectively communicating societal dependence on ecosystems (Haines-Young and Potschin, 2013; La Notte et al., 2017). CICES is currently a reference system for ES classification, particularly in Europe (La Notte et al., 2017; Mascarenhas et al., 2016), being used as base at national level ecosystem assessment in Belgium (Turkelboom et al., 2013), Germany (Naturkapital Deutshland - TEEB DE, 2014) and Finland (Lee and Lautenbach, 2016; Mononen et al., 2016).

Similarly to the TEEB classification, the support services originally from the MEA framework is no longer a group category, instead it becomes a function as it is considered by the cascade framework (Haines-Young and Potschin, 2013), and merges the TEEB habitat services with regulating services , in a category called regulating and maintenance services (La Notte et al., 2017; Sen et al., 2014). This categories are then grouped in supporting/intermediate services and final services according to its susceptibility of provide direct benefits to human well-being (Haines-Young and Potschin, 2013). It provides a clear distinction between ES and ecosystem benefits (La Notte et al., 2017) focusing only in the final Ecosystems Services (the directly consumables) avoiding the ES double-counting (Schwilch et al., 2016). Although its considerable contribution for the standardization of the ES definitions (La Notte et al., 2017), being based on mostly natural sciences, causes a weak inclusion of social aspects, and it has become rather complex, with extensive use of specialized terminology (Schwilch et al., 2016). These features allows stake holders holding different types of knowledge to be able to refer to specific or general ES classes of ES while it increases the complexity of data analysis (Mascarenhas et al., 2016). The newest available tool is currently at version CICES 4.3 (Haines-Young and Potschin, 2013).

One of the existent ES classification frameworks main difference resides on the distinction whereas the ES is classified as intermediate or as final service (La Notte et al., 2017; Landers and Nahlik, 2013; Mononen et al., 2016; TEEB, 2010; UKNEA, 2011). There is yet a need for a more clear distinction between intermediate and final ES to avoid the double counting of ES benefits aggregation, and adequately count only the aggregated benefits from the final services (Boyd and Banzhaf, 2007; de Groot et al., 2012; Fisher et al., 2009; Heink et al., 2016; La Notte et al., 2017; Schwilch et al., 2016).

3. METHODOLOGY

3.1. Case studies

A selection criteria aiming to demonstrate the newest situation regarding the current EIA procedures and methodologies for the discussed subjects on this work was adopted through both a qualitative and a quantitative approach.

All the included EIA cases are chosen according to the realization date of its assessment report on the execution or exploitation phase, the Environmental Impact Statement (*Relatório Técnico/Síntese* in the Portuguese legislation) ranging from 2016 to 2017 allowing an up-to-date review. Then considering the EIA type according to classification of the annex I and II (*Anexo I* and *Anexo II*) of the Portuguese statutory law Statutory Law *Decreto-Lei n. º 151-B/2013,* a selection of a minimum of one and a maximum of two cases from each area was randomly selected, including one case that although did not required, it was subjected to the EIA practice, all collected from the publicly available archived EIA documents in participa.pt and the APA websites. The chosen classification area is defined at member state level since there is no area classification standard for all EU member states (2013; 2013). A total number of fourteen case studies were selected, all with requiring EIA procedure excepting case number five, and also, apart from case number eleven which its EIA is under the exploitation phase, all the other are under execution project phase. A description of each case here presented, including the designation, specifications and location shown below:

Case 1 - "Sobre Equipamento do Parque Eólico de Testos" involves the installation of two windmills to provide electric energy. This project comprise two different counties: First the Monteiras Parish, Castro Daire County, and second the Lazarim Parish in Lamego County, both from Viseu District.

Case 2 - "Central a Biomassa de 10 MW, em Corga de Fradelos, Vila Nova de Famalicão" comprises a biomass plant to provide electric energy. It is located in Farelos Parish, Vila Nova de Famalicão County, Braga District.

Case 3 - "Projeto de Melhoria da Acessibilidade ao Porto de Setúbal" consists in the improvment of the sea acess for container ships to an already existing sea port. The project involves the Setúbal Parish (São Sebastião) and the União das Freguesias de Setúbal Parish (São Julião, Nossa Senhora da Anunciada e Santa Maria da Graça), both from Setúbal County, Setúbal District.

Case 4 - "Empreendimento Herdade da Rendeira" consists in a dam for water storage purposes, involving two different counties from Évora District. First the "Herdade da Rendeira" located in Santiago Parish, Alandroal County, and second, the Corval Parish, Évora District.

Case 5 - "Estudo de impacte ambiental “mina de corte pequena”" involves a quarry for the extraction of nepheline syenite minerals. Located in Alferce Parish, Monchique County, Faro District.

Case 6 - Licenciamento da Pedreira “Daroeira Nova” it comprises the extraction of sand by mining. Located on both União das Freguesias de Alcácer do Sal (Santa Maria do Castelo e Santiago) and Santa Susana Parish, Álcacer do Sal County, Setúbal District.

Case 7 - "Fábrica de Papel "Tissue" (Vila Velha do Rodão)" consists in an industrial plant for the production of tissue type paper. Located in Vila Velha de Ródão Parish, Vila Velha de Ródão County, Castelo Branco District.

Case 8 - "Unidade de Produção de Detergentes da Clorosol" involves a facility for the production of hygiene and cleaning products. Located in União das Freguesias de Lemenhe, Mouquim e Jesufrei Parish, Vila Nova de Famalicão County, Braga District.

Case 9 - "Nova Unidade Industrial de Produção de Injectáveis dos Laboratórios Basi" consists in a facility for the manufacturing of pharmaceutical products. Located in União das Freguesias De Mortágua, Vale De Remígio, Cortegaça e Almaça Parish, Mortágua County, Viseu District.

Case 10 - "Aquicultura da Praia da Tocha" consists in the expansion of an already existent intensive aquiculture infrastructures, aiming to increase the flounder fish production. It is located in Toucha Parish, Catanhede County, Coimbra District.

Case 11 - "Instalação avícola do Casal Seiça, em Lavos – Figueira da Foz" consists in the expansion of an already existing poultry facility, aiming for increasing its production numbers. Located in touch Parish, Catanhede County, Coimbra District.

Case 12 - "Projeto do Empreendimento Agroturístico do Monte dos Adães – 3ºFase" involves a holiday village and a caravan campisite for tourism purpoises. Located in Nossa Senhora da Graça dos Degolados Parish, Campo Maior County, Portalegre District.

Case 13 - "Álcacer Vintage" consists in a holiday village for tourism purpoises. Located in União das Freguesias de Alcácer do Sal e Santa Susana Parish, Alcácer do Sal County, Setúbal District.

Case 14 - "METALOCARDOSO – Construções Metálicas e Galvanização, S.A." consists in an installation for the production of metallic elements and surface treatment of metals. Located in Fregim Parish, Amarante County, Porto District.

In Table 4 all the EIA sample cases are classified according to their respective category by the *Anexo I* and *Anexo II* of the *Decreto-Lei* 151-B/2013(2013), except for case number 5 that do not require EIA procedures.

Table 4 - Case sample categorization according to Anexo I and Anexo II of the Decreto-Lei 151-B/2013 (2013)

Case	Annex	Annex category	Category description
1	II	3 - Energy industry	i) Installations for the harnessing of wind power for energy production (wind farms);
2	II	3 - Energy industry	b) Industrial installations for carrying gas, steam and hot water; transmission of electrical energy by overhead cables (projects not included in Annex I);
3	II	10 - Infrastructure projects	n) Dredging, except for those provided for in c) of point 2 f) of point 10 and maintenance dredging of the conditions of navigability not exceeding background quotas previously achieved
4	II	10 - Infrastructure projects	g) Dams and other installations designed to hold water or store it on a long term basis (projects not included in Annex I);
6	II	2 - Extractive industry	a) Quarries, open-cast mining and peat extraction (projects not included in Annex I);
7	II	8 - Textile, leather, wood and paper industries	a) Industrial plants for the production of paper and board (projects not included in Annex I);
8	II	6 - Chemical industry (projects not included in annex i)	a) Treatment of intermediate products and production of chemicals;
9	II	6 - Chemical industry (projects not included in annex i)	b) Production of pesticides and pharmaceutical products, paint and varnishes, elastomers and peroxides;
10	II	1 - Agriculture, Silviculture and aquiculture	f) Intensive fish farming;
11	I	23 - Installations for the intensive rearing of poultry or pigs with more than	a) 85 000 places for broilers, 60 000 places for hens;
12	II	12 - Tourism and leisure	c) Holiday villages and hotel complexes outside urban areas and associated developments; d) Permanent campsites and caravan sites;
13	II	12 - Tourism and leisure	c) Holiday villages and hotel complexes outside urban areas and associated developments;
14	II	4 - Production and processing of metals	b) Installations for the processing of ferrous metals: (iii) application of protective fused metal coats; e) Installations for surface treatment of metals and plastic materials using an electrolytic or chemical process;

Moreover the information regarding each projects' services provided, sensitive area inclusion, implemented area values and the report (*Relatório Técnico/Síntese*) development year is shown on Table 5.

Table 5 – Environmental Impact Assessment sample case studies information

Case study	Project goods/services produced	Sensitive case area	Implementation area (m^2)	Report Development Year
1	Energy	No	3568	2016
2	Energy	No	6500	2016
3	Acessibility	No	200000	2016
4	Goods	No	1246000	2017
5	Raw materials	No	59000	2016
6	Raw materials	No	90200	2016
7	Goods	Yes	130000	2016
8	Goods	No	3867,3	2017
9	Goods	No	63256	2016
10	Goods	Yes	100000	2016
11	Goods	No	46570,3	2016
12	Tourism	No	23200	2016
13	Tourism	No	351000	2016
14	Goods	No	66250	2016

3.2. Data analysis procedures

The first analysis of the EIA sample cases focuses on determine the existence of environmental resources valuation through a combination of ES classification framework and one or more valuation methods application. Any reference to an ES classification framework is weighted if it is mentioned in the respective case study and thus considered explicitly cited, as well as proceeded with the application of one or more valuation methods already cited in this work and presented in monetary values.

The next step focuses on the implementation of an integrated methodology for the environmental resources valuation in the EIA case studies. Beginning with understanding of how the current EIA structure may integrate an ES classification framework, proceeded with the identification of the ES and abiotic outputs according to CICES classification framework (Haines-Young and Potschin, 2013) within the EIA sample cases, and therefore organize them conforming to that framework. After that classification process, the choice of a valuation method to the ES and abiotic outputs identified in the EIA sample cases is performed aiming for a possible standardly use of this approach in future EIA projects.

Lastly in order to demonstrate the practical application of an integrated methodology for the environmental resources valuation in the EIA case studies, the previously chosen valuation methodology is applied on a given ES commonly identified in a group of EIA case studies.

4. Results and Discussion

4.1. Analysis and Ecosystem Services classification

The first analysis on the total case studies focused on the detection of ES valuation methodologies comprising the adoption of an ES classification framework considering the MEA, TEEB, CICES or another one that has been explicitly cited, combined with one or more valuation methods cited in this work. The outcome was negative for all the analysed case studies allowing to conclude that there is not any kind of applied ES valuation methodologies, furthermore it was not observed any kind of valuation methods considered or standard ES framework in this work applied to the environmental resources of each EIA case. Obtaining this results and having the ES assessment insight, the following understanding of how the current EIA structure is susceptible to integrate an ES framework, highlights the need of establish a link between the EIA components and ES classification. For that a relationship table between EIA environmental factors and ES (adapted from a previous MEA category based study (Honrado et al., 2013) and modified according to the CICES framework (Haines-Young and Potschin, 2013)) is established and displayed in Table 6. This provides guidance through the analysis on each study case for the presence of any type of reference or assessment to the ES in Table 7 supporting further possible ES valuations.

Table 6 - Equivalences between the structure of Environmental Impact Assessment and Ecosystem Services categories: (0) no conceptual relationship expected; (+) significant relationship expected; (++) very significant relationship expected (adapted and modified from Honrado *et al*. 2013 (Honrado et al., 2013))

EIA	Ecosystem services categories			
	Final Ecosystem services			Ecosystem processes/intermediate services
Environmental factors	Provisioning (P)	Regulation and Maintenace (RM)	Cultural (S)	Support (S)
	Biomass (Nutrition) Biomass (Materials from plants, algae and animals for agricultural use)	Atmospheric composition and climate regulation Mediation of gaseous/air, mass and liquid flows	Physical and experiential interactions Intellectual and representational interactions	Lifecycle maintenance, habitat and gene pool protection Soil formation and composition Maintenance of water conditions
Air quality	0	+	0	+
Climate	+	+	0	+
Noise	0	0	+	0
Landscape, land use and geomorphology	++	+	++	+
Geology	0	+	+	+
Soil	+	+	0	+
Water resources	+	+	++	+
Fauna/ flora/ habitats	+	+	++	++
Land planning/ resctrictions	+	++	+	+
Cultural heritage	0	0	++	0
Structuring systems	0	+	0	+
Socio-economics	++	+	++	+
Demography	+	+	+	+

Table 7 - Table of assessments or references related to Ecosystem Services in the fourteen studied cases according to the CICES Ecosystem Services final services classification (the Ecosystem Services that directly generate benefits) (Haines-Young and Potschin, 2013)

	ES categories and subcategories	Study cases														References to ES classes
	Final services	1	2	3	4	5	6	7	8	9	10	11	12	13	14	
Provisioning	Biomass (Nutrition)	X	X	X	X	X			X				X			Cultivated crops (8,12); Wild animals and their outputs (1,3,4); Surface water for drinking (5); Ground water for drinking (2,5); Reared animals and their outputs (4);
	Biomass (Materials)	X	X		X	X			X		X		X	X		Considerations on the negative impact in areas suitable for forest occupation (1); Surface water for non-drinking purposes (5,8); Ground water for non-drinking purposes (2,5,10,12,13); Fibres and other materials from plants, algae and animals for direct use or processing (2); Surface water for non-drinking purposes (4);
Regulation & Maintenance	Mediation of liquid flows	X	X		X	X						X				Hydrological cycle and water flow maintenance (1,2,4,5,11); Flood protection (4);
	Mediation of mass flows	X	X	X	X		X	X		X		X	X	X	X	Mass stabilisation and control of erosion rates (1,2,4,6,7,9,11,12,13,14); Buffering and attenuation of mass flows (4,12,3)
	Atmospheric composition and climate regulation	X	X							X			X			Micro and regional climate regulation (1,2,9,12)
	Maintenance of physical, chemical, biological conditions			X	X	X	X	X			X	X	X	X		Maintaining nursery populations and habitats (3,4,5,7,10,11,12,13); Weathering processes (6); Decomposition and fixing processes (7); Micro and regional climate regulation (6,7)
Cultural	Physical and intellectual interactions with biota, ecosystems, and land/seascape	X	X	X	X	X	X	X	X	X	X	X	X	X	X	Experiential use of plants, animals and land-/seascapes in different environmental settings (12); Physical use of land-/seascapes in different environmental settings (1,3,4,12,13); Educational (12); Heritage, cultural (11,13); Entertainment (12); Aesthetic (1,2,3,4,5,6,8,7,9,10,11,12,13,14)
	Spiritual, symbolic and other interactions with biota, ecosystems and land-/seascapes					X		X			X		X			Bequest (5,7,10,12); Existence (5,7,10,12);

Both the ES assessments and references considered may be part of any component of the set of documents integrating the EIS report (*Relatório Síntese/Técnico*), being based on the implicit or explicit written considerations and cartography or images related to any ES and abiotic ecosystem outputs defined by the CICES categories regarding the final services due to be considered as the ones that generate benefits. Only the final ES are considered given the CICES principle of preventing benefit double counting (Haines-Young and Potschin, 2013), ignoring the Honrado *et al.* (2013) (Honrado et al., 2013) study Supporting ES based on the MEA. Specifically it will be taking into account expressions such as “ecosystem services”, “ecosystem goods and services”, “ecosystem goods” and “abiotic ecosystem outputs” as explicit references, being all the other less subject related mentions considered as implicit references.

Additionally the abiotic assets table of EIA references, following the same criteria, provides the information regarding all the environment functions capable of being valued, usually with market prices, such as minerals for food or industry, renewable and non-renewable energy sources, summarized in Table 8.

Table 8 - Table of assessments or references related to the abiotic ecosystem outputs in the fourteen studied cases according to the CICES framework classification (Haines-Young and Potschin, 2013)

	Division	Study cases														References	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	Groups	Examples
Abiotic Provisioning	Abiotic materials					X	X									Non-metallic	Minerals (5,6)
	Energy	X														Renewable energy sources	Wind (1)

4.2. Application of the valuation method

The valuation method applied on the case studies is the benefit transfer by the very reason that there is a lack of previous site specific ES valuation studies in general, and for the given specific contexts of the case studies analysed in this work. Also to achieve a possible integration of ES valuation on EIA procedures, as it has been previously stated in this work, the economic and time saving features of relying in already existing studies constitutes an advantage for policy making decisions. To ensure the validity of this approach the temporal and spatial context must be most similar as possible due, as previously stated, to the estimates accuracy tends to decrease alongside with the difference in either of this factors between the original study and the study case from which the benefits are transferred (de Groot et al., 2012; DEFRA, 2007; Tietenberg and Lewis, 2011). The temporal context is a relatively simple, easy to choose, being the study case with the same realization date the preferred one. The spatial scale in the other hand must take into account the local economic value of a service will be very different depending on the livelihood circumstances, income levels and other socio-economic conditions such as price levels, population density (Barrio and Loureiro, 2010; Brander et al., 2006; Shrestha and Loomis, 2001), distances between beneficiaries and the resource, accessibility, and the presence of substitute and complementary sites (de Groot et al., 2012; Ghermandi et al., 2010). After emphasising the main aspects of the value transfer approach, a framework for its application must be adopted in order to be used as standard procedure to any other future case study.

There are two different approaches when applying the benefit transfer method, the single-best-study approach where estimated average WTP from the study context of a given study site that most matches the policy site (Santos, 2007), in this case the study sites belonging to the group or each case of the chosen EIA projects. In this work a bibliographic review of site case studies on valuation of ES with preference to ES with non-market values, previously referred in this work as the most difficult to valuate, included in Table 7, and ranging more than one different sample EIA case study. After choosing the appropriate study site case, one may not require to not adjust the WTP estimates to the policy site, being the optimum option for the benefit transfer method, or it may need to perform an adjustment of some of the determinants of value, or even use a WTP function to perform a more extent adjustment of those determinants. Then, once the WTP values have been estimated for the policy site, they need to be aggregated over the population relevant to the policy site, in this case, the population relevant to the EIA project. The Department for Environment, Food and Rural Affairs (DEFRA) provides a good example of an existing framework in the form of a guide for ES valuation where it suggests the benefits transfer procedures to be performed in a first phase for the single-best-study approach in four steps as it shown in the table below (Table 9) (DEFRA, 2007).

Table 9 - Steps for the Ecosystem Services benefit transfer valuation approach adapted from Department for Environment, Food and Rural Affairs, 2007 (Department for Environment Food and Rural Affairs, 2007)

Ecosystem services benefit transfer valuation framework	
Step 1. Literature review	This is undertaken to find appropriate valuation studies that might be applied to the policy context. There are a number of databases that provide information on relevant studies that might be used for benefits transfer.
Step 2. Selection of appropriate study	The study site should be as close a match as possible to the policy context if the results from the transfer are to be useful and credible. This is a crucial aspect of the benefits transfer process.
Step 3. Adjustment of WTP values	If necessary, using the income or function transfer may be used.
Step 4. Aggregation	Once WTP values have been estimated for the policy site, they then need to be aggregated over the population relevant to the policy context. Careful consideration should be given to any populations that derive non-use values, in addition to those who derive use values.

The single-best-study approach is very rarely available in practice for most benefit transfer problems (Santos, 2007) fact that was verified in this work as the literature review has demonstrated, there were no single study that matched the temporal and spatial context altogether of the policy site.

When there is no single best study, as it is the case, it is better to transfer multiple studies rather than a single one, being the multiple studies approach the best option to apply in this case (Santos, 2007). This approach manage to convey more information by transferring the average or other more complex model of multiple studies and enables one to avoid the unpredictable effects on the benefit transfer of a more or less arbitrary selection of one single study, plus more or less arbitrary adjustments to the selected estimate (Santos, 2007).

After consider over this two benefit transfer approaches (summarized in Table 10) a multiple studies approach was chosen, allowing the valuation of one identified class of ES shared by more than one EIA case sample from Table 7.

Table 10 – Single-study-approach and multiple studies approach of benefit transfer method adapted from Department for Environment, Food and Rural Affairs, 2007 (Department for Environment Food and Rural Affairs, 2007)

Benefit transfer method	
Transferring single-best-study-approach	
Average WTP estimate	Uses the estimated adjusted or unadjusted average WTP from the study context.
Unadjusted average	Assumes that the average WTP is applicable both at the study site and the policy site, ignoring the possibility of for instance, the socio-economic characteristics of the populations, the physical characteristics of the sites and the valuation context may be different.
Adjusted average	Adjust the WTP estimates for differences between the original study and the policy context.
WTP function	Makes more extensive adjustments to account for the differences in the principal determinants of value such as the service provided, the socio-economic characteristics of the affected population and the valuation context. The resultant WTP is therefore more relevant to the policy context.
Transferring multiple studies approach	
WTP estimates from meta--analyses	Statistical method using estimates across single site studies to build a regression function which relates the monetary value of the ES with a number of explanatory variables meant to influence their value.

The ES valuation study by Ding *et al.* (2016) (Ding et al., 2016) was chosen mostly due to its valuation of a non-marketed ES shared between several EIA case samples in this work, and matching through the meta-analysis of the benefits transfer method, the policy site of those EIA case samples. Plus this study captures the recreational values of forests and prediction of different estimates under different development scenarios of the Intergovernmental Panel on Climate Change (IPCC) because climate changes are considered to be one of the most contributor to the biodiversity loss and evidences suggest that it tends to increase at an accelerated rate (MEA, 2005; Ojea et al., 2010). In this specific example it will be used the option of the ES recreational value without the implementation of the project. The approach of applying general habitat values, to specific habitat types (DEFRA, 2007) is used in a broader scale, assuming all the sample EIA site habitats have the same geographical group of Mediterranean forest biome values with the basic benefit transfer method. This means the spatial scale is considered to be similar between the Chosen Ecosystem Services Valuation Study (CESVS) and the chosen EIA sample studies, which increases its accuracy. Although this assumptions, the CESVS case is based on the MEA ES classification, which have being adapted to the CICES classification by the help of the equivalence framework available on the Biodiversity Information Center of Europe (BISE) website (Biodiversity Information System for Europe, 2017) that relates both ES framework categories results in the adapted version of this equivalence system on Table 11.

Table 11 - Excerpt of Ecosystem Services category equivalences between MEA, TEEB and CICES frameworks from BISE website 2017 (Biodiversity Information System for Europe, 2017)

MA categories	TEEB categories	CICES v4.3 groups
Recreation and ecotourism	Recreation and tourism	Physical and experiential interactions

After that conversion the considered MEA recreational values of the valuation study became under the CICES classification, the physical and experiential interactions group of cultural services division, which includes the experiential use of plants, animals and land/seascapes in different environmental settings.

As it can be observed in Table 11 the Recreation and ecotourism values according to the MEA framework from the CESVS are equivalent to the CICES Group Physical and experimental interactions which includes both Class Experiential use of plants, animals and land/seascapes in different environmental settings, and the Class Physical use of land/seascapes in different environmental settings. Said that case studies number 1, 3, 4, 12 and 13, refer activities such as walking, hiking, leisure hunting and in-situ bird watching, etc. included in both of those ES classes making them apparently viable options, but since the CESVS is directly related to forest areas, only the case 1, 4 and 13 mention affected forest areas, and thus being valid for the valuation method application.

The temporal scale of the given ES valuation study (2016) matches most of the EIA sample case studies, but in terms of monetary results from the valuation study, it ranges from 2000 to 2050, being the first year too distant from the average EIA sample dates but the 2050 are calculated with 2016 estimative values.

The CESVS considers four different climate change development scenarios (storylines) according to IPCC (Table 12) and estimates a range of values for estimated population, carbon dioxide concentration, average temperature, average precipitation and socio-economic dimensions of the European forests for each Geographical region considered from Mediterranean, Central, Northern and Scandinavian Europe (Ding et al., 2016).

Table 12 – The specifications of the four IPCC storylines from Ding *et al*. 2016 (Ding et al., 2016)

Indicator	Climatic model–HadCM3 (Scenarios by 2050)			
	Storyline A1FI Global economic	Storyline A2 Regional economic	Storyline B1 Global environmental	Storyline B2 Global environmental
Population (10^6)	376	419	376	398
CO_2 concentration (ppm)	779	709	518	567
Δ Temperature (ºC)	4.4	2.8	3.1	2.1
Δ Precipitation Europe (%)	-0.5	0.5	4.8	2.7
Socio-economic dimensions	High savings and high rate of investments and inovation	Uneven econimic growth, high per capita income	High investment in resource efficiency	Human welfare, equality, and environmental protection

The original estimated values in dollars for each climate change scenarios for the initial year of 2000 and the final year of 2050 from the CESVS are adapted and converted to euros according to the 2005 average exchange rate of the EU commission (Millington, 2007) (due to the original work use of 2005 US$ currency values) and presented in Table 13.

Table 13 - Adapted projections of marginal recreational values of European forests in €/ha/yr from Ding *et al.* 2016 *(Ding et al., 2016)*

Geographical Regions	Development Scenarios (IPCC)				
	Year 2000 Initial	Year 2050 A1	A2	B1	B2
Mediterranean Europe	0,87 - 2,50	1,02 - 6,42	1,03 - 6,46	0,98 - 7,54	0,84 - 5,53
Central Europe	0,35 - 2,13	0,87 - 6,65	0,56 - 4,22	0,66 - 6,60	0,53 - 3,94
Northern Europe	1,53 - 5,80	3,40 - 81,57	3,29 - 78,82	3,24 - 101,50	2,42 - 51,06
Scandinavian Europe	0,13 - 0,86	0,19 - 0,43	0,19 - 0,44	0,22 - 0,60	0,18 - 0,36

As previously stated all EIA geographical regions are considered to be of Mediterranean Europe, thus all the selected three sample cases namely case number 1, 4 and 13 use the correspondent values from Table 13, assigned according to the EIA forest area within the implementation area during the exploitation phase of the project and presented in Table 14.

Table 14 - Valuation of the physical use of land-/seascapes in different environmental settings of the selected Environmental Impact Assessment case studies in €/ha/yr

Case study	Forest area (ha)	Development Scenarios (IPCC) for Mediterranean Europe														
		Year 2000			Year 2050											
		Initial			A1			A2			B1			B2		
1	0,0597	0,05	-	0,15	0,06	-	0,38	0,06	-	0,39	0,06	-	0,45	0,05	-	0,33
4	13,3895	11,59	-	33,45	13,66	-	86,02	13,77	-	86,46	13,12	-	101,00	11,26	-	74,00
13	7,697345	6,66	-	19,23	7,85	-	49,45	7,92	-	49,70	7,54	-	58,06	6,47	-	42,54
Total	21,146545	18,30	-	52,82	21,58	-	135,86	21,75	-	136,55	20,71	-	159,51	17,78	-	116,87

These results correspond to the area of the baseline option or option zero, namely the development of the current scenario without any project implementation providing monetary values of the environmental resource that is directly affected by the implementation of the given project.

4.3. Interpretation of results

The adoption of an equivalence table between the EIA factors and the CICES ES classification (Table 6) was considered to provide guidance over the expected ES references in each case and at the same time to allow to visualize where in the future, having implemented an ES framework, the explicit references of the mentioned ES may possibly be applied. In this very same table (Table 6) it is shown that it is expectable to have a larger identification and analysis of the ecosystems under the project's influence (Honrado et al., 2013), becoming more evident when compared with the referred ES as it is observable in Table 7. As it is shown in this table of results, the cultural services are the only ES implicitly present in all the case studies due to its references being commonly framed in the aesthetic class, also all those references can be found in the landscape, land use and geomorphology factors of the EIA cases, being that as it can be observed in Table 6, there is a very significant relationship between these factors and the group of intellectual and representational interactions belonging to the class cultural services. This mentioned result was the best outcome for the expected correlation between EIA factors and ES categories, although this positive correlation still verifies in the remaining references of each case, it is notorious the low amount or even absence of certain references within the three considered ES categories (the sections provisioning, regulation and maintenance, and cultural). That said, and in contrast with the previous example, the socioeconomic factor which is expected to have a very significant relationship with the provisioning and cultural services, and a significant relationship with the regulation and maintenance services, did not present any references within the expected categories in neither case. This may imply that the socioeconomic factor has the potential to include some ES components but in practice that does not verifies, given the majority of the socioeconomic factors in the EIA cases addressing mainly to the statistical data regarding the human population situation of the given parish, county or district.

Beside the ES aesthetic class references common to every sample case, observing Table 7 the classes of mass stabilisation and control of erosion rates and the maintaining nursery populations and habitats biological conditions are the most frequent ES in the sample study cases. There are two different interpretations about this results, the first one is that this ES are taking into account for its relevance on impact assessment, the second one, is that analysing all together the rest of the ES implicit references in Table 7, there is already an ES assessment in a non-systematic form, without a structured classification, in the EIA case studies. This last interpretation suggests that the distance between the current EIA practice and an integration of an ES classification framework is only a matter of defining and classifying already assessed ES susceptible of impacts by the project. Although the EIA developers demonstrate qualifications to assess ES, the implementation of this procedures would require the learning of new skills and already associated costs. In the other hand the applicability of the valuation methods for those considered ES may be more difficult to achieve, since it is considered to be a pioneer component for this EIA.

As it can be verified there are no references on Table 6 regarding the abiotic ecosystem outputs classification due to the original study did not include those, since it follows the MEA ES classification (Honrado et al., 2013) which opposing to CICES classification, it excludes this abiotic factors. The specific references on abiotic ecosystem outputs observable in Table 8 can easily be associated with the specific environmental resource exploitation for each EIA case study, given the case number 1 of the windmills farm resort to wind energy, case number 5 and 6, both mining projects extracting nepheline syenite and sand (minerals) respectively.

It must be considered the possibility of Table 6 to be biased due to its original study case only considered twelve EIA case studies of wind farms and hydroelectric projects, both related to energy production (Honrado et al., 2013), similarly to case study 1 and 2, possibly not being compatible with a wider composition of different categories of EIA projects. This potential issue may explain the contrasting outcomes regarding the expected relationship between the EIA factors and the identified ES sections.

The large discrepancy in the observed monetary values between smaller and larger forest areas can be explained due to the fact that CESVS assumes that the marginal value decreases with an increase in the forest size, and increases with an increase of the income in the country where the forest is located (Chiabai et al., 2011; Ding et al., 2016; Hammitt, 2000).

The preferential meta-analysis application for the example of the ES valuation in this work, would be to transfer a flexible function capable of providing the introduction of specific factors for given policy site, such as the visitor rate (the number of visitors by the area of the forest where the project is located) and variables that may contextualize the given policy site, such as the site uniqueness or the type of population visiting the site, for instance locals our foreign visitors. This would correspond the aggregation step from Table 9 where after the adjusted WTP values, the policy site relevant population including in for example, the visitor rate factor, and then in this case, applied to the forest area directly affected by the implementation of the given EIA project. Unfortunately the meta-regression function of the CESVS lacks of flexibility, allowing two options, the first one to create a new meta-regression function using the CESVS original site study cases and adapt it to the policy studies, or as the time consuming and complexity of this option is impracticable for this work, the option of adapt only the available controlled factor, the geographical habitat biome, thus ignoring the aggregation step and multiplying with the forest area directly affected by the implementation of the given EIA project. Moreover the fact that the monetary values correspond to WTP by area and not by visitor, makes the visitor rate factor unfeasible to apply even with a flexible meta-regression function. All together these limitations increase the biased results of the application of the CESVS in the EIA sample cases of this work, an outcome cause by the uncontrolled factors and variables this transfer process.

As it can be observed after the valuation of the cultural services (Table 14), which represents only a small fraction of the potential ES that can be valued on the sample EIA cases, a monetary value, and part of the TEV can be presented. The sum of the valued cultural services of case number 1, 4 and 13 are estimated to achieve potential maximum annual value of 135,86 euros for each hectare of terrain, a value that most possibly would not be unnoticed by the decision makers during the assessment of that ES. Many ES such like cultural services are excluded from formal economic decision making and therefore undervalued and overexploited, leading to a gap in the literature and an almost non-existent articles regarding the valuation of this ES (Jónsson and Davíðsdóttir, 2016; Pietrzyk-Kaszyńska et al., 2017)

Honrado (2013) realized there was no relationship between the EIA that included protected areas (National Network of Protected Areas or EU Natura 2000 Network) and a larger quantitative reference to ES (Honrado et al., 2013), whereas in this study apparently it also does not exist. Furthermore expected ES classes related to forest areas, such as mass stabilization and control of erosion rates, micro and regional climate regulation, maintaining nursery populations and habitats, bequest and existence, are not fully covered by the case number 7 and 10, which are implemented on protected areas that includes forests. Being those two cases surpassed in terms of quantitative different ES classes covered by the case number 12 that includes the range of mentioned ES classes, including the micro and regional climate regulation of which case number 7 and 10 are deprived.

Between the observable values in Table 14, the obtained values for the EIA case number 13, Álcacer Vintage, being a rural tourism project, the value of "the physical use of land-/seascapes" of the project's main option could be superior to the baseline option estimated here. Also it can be verified that certain types of habitats, such as the Mediterranean Europe considered here, have a great financial potential associated given its observed large monetary values which in the same context, is only surpassed (greatly) by the Northern Europe habitat.

As in the study of Honrado (2013), although all the ES references in the analysed sample EIA are implicit, there are enough data to perform some quantifications and/or mapping of some ES (Honrado et al., 2013) such as the global climate regulation by reduction of greenhouse gas concentrations in forests (Regulation and Maintenance accordingly to CICES) included in some of the studied EIA cases, for instance case number 4, although that was not the objective of he given application example on this work, instead focusing in the present ES references.

Similarly to Honrado (2013) the analysed sample, representative of the most recent performed EIA in Portugal, there seems to exist an under-representation of the ES, which when present, these are all in implicit form (Honrado et al., 2013). The clarity of how the information is presented and comprehended by those who are going to use and explore it is important in evaluating the pertinent issues, being that an approach to the inherent problems in an evident and explicit form, makes it possible to have a fast comprehension, reducing the hypotheses of these to pass unnoticed (Honrado et al., 2013). It was considered that the explicit consideration of the ES as an evaluation tool in the EIA promotes more coherent and integrative assessments of impacts and cost-benefit analysis.

In all the observed samples there is no adoption of any kind of ES framework to perform ES assessment, although the case study number 12 namely the "Projeto do Empreendimento Agroturístico do Monte dos Adães – 3ºFase", refers to the MEA but only to highlight the importance of ecosystems protection, thus not following the MEA definition and classification of the ES.

When the literature review was performed, I came across to a considerable limitation regarding the conjoint EIA analysis capability between the EU member states, as it is described in the EIA directive (Directive 2014/52), "With a view to strengthening public access to information and transparency, timely environmental information with regard to the implementation of this Directive should also be accessible in electronic format" (2014), which facilitates the participation on undergoing EIA projects' assessments, but lacks in the obligation of provide these documents in a free and permanent form in electronic format. The limitation here stated focus precisely on the availability of each member state has in allowing the collection of a given number of elements (EIA documents) for sampling analysis that fortunately it verifies in Portugal, specifically for this work, but also as it is for Spain. The documents provides by these countries do not constitute the totality of performed EIA subjected projects but it constitutes a viable sample anyway, given the variety of different category projects defined by regional legislation, as it is in Portugal under the *Anexo I* e *Anexo II* of the *Decreto-Lei* 151-B/2013 (2013).

It is considered important to quantify the ES though the mapping and valuation in the assessment process of the ES in EIA (Honrado et al., 2013). The choice of a framework such as CICES to analyse the quantity and quality of the final ES is required according to the United Kingdom National Ecosystem Assessment (2014) in order to evaluate the impacts on the economic sectors, being its macroeconomic performance dependent on the changes in ES qualities and quantities (UKNEA, 2014). The adoption of an integrated framework institutes challenges to its implementation as it is described by the UKNEA (2014), starting with the necessary resources and capabilities for its application, including the lack of data, time, money, qualifications, formation, and guidance for those who performs the EIA (UKNEA, 2014). Regarding the available data, it is evident that the more number of case studies are performed, the more data will be available, being suggested the existence of more integrated data sets to improve the knowledge on this matter (UKNEA, 2014). Honrado (2013) considers that an integrated framework for the ES assessment allows a more systematic consideration of the ES in order to improve the EIA practice (Honrado et al., 2013). In a complementary way, UKNEA (2014) states that the inclusion of an ES framework in the EIA could be accomplished by the revision of the EIA directive, but if not possible, it suggests the provision of demonstrating projects that exemplify the inclusion of an ES framework in the improvement of the impact assessments, without compromising the legislation in force (UKNEA, 2014), what may represent an alternative solution for Portugal or any other state member. This work may serve as a demonstration of the application of an ES framework integration in the EIA procedures, considering that it does not transgress any regulations regarding the EIA, being an addition to the current standard EIA process. Thus a standardised integration of methodologies covering the total costs and benefits of new projects may limit the flexibility of decision makers to make a decision averse to the public interest (Cook et al., 2016). But at the same time one must be aware that the decision makers are sceptical of methods they see as complex and opaque (Villa et al., 2014). However the development of a framework with clearly defined and consistently used terms is critical to their perceived value (Friedrich et al., 2015; Lemasson et al., 2017; Schwilch et al., 2016) accompanying of an existence of a consensus on the adopted policies/methodologies is required for an EU ES framework (Maes et al., 2016). The reason is that its implementation policies currently depend upon each EU state member, meaning that although the work coordination framework of the EU, the methodologies towards the ES assessment approaches are still set at national level (Arcadis Belgium, 2011; Maczka et al., 2016), its application is considered arbitrary and highly diversified in terms of methodology (Maczka et al., 2016; Seppelt et al., 2011). Under development, The EU Biodiversity Strategy to 2020 following the 2006 EU Biodiversity Action Plan, will set a new focus on ES, targeting amongst other subjects, the full implementation of the EU nature legislation, providing thus an ES assessment framework at EU level, and directly or indirectly promoting the valuation of those services (European Comission, 2011).

Several authors refer to the great need of distinguish between intermediate and final ES, a clear separation of the services that provide benefits for the people and the ones that provide those services (DEFRA, 2007; Jónsson and Davíðsdóttir, 2016), and CICES apparently is the obvious choice to fulfil that need. The choice of this framework for this work and other studies and applications incurs in its capability to embrace a larger part of the natural capital than the previous ES frameworks. CICES considers abiotic services and outputs such as the mineral provisioning through mining or the wind energy capture, both comprised in sub-soil assets and abiotic flows, that may affect the ES (European Comission, 2013). Basically CICES incorporates the quantification and qualification of ES and the remaining outputs and services provided by the environment for the human being, allowing to classify a wider range of environmental resources, such as the provisioning of energy from case number 1, or of minerals from case number 5 and 6, for posterior valuation.

Some of the general problems associated to the valuation applied to the EIA includes the difficulty in evaluate the credibility of the application estimative from a single study or method, due to inconsistent or biased questionnaires, or to be influenced by budgets limitation. Results with similar values obtained from different case studies regarding the same environmental resources under valuation, may improve its credibility (Her Majesty's Treasury, 2011). This measures might be adopted not by performers of the EIA projects, but by the decision makers to confirm, or reduce doubts regarding valuations those project, facilitating the decision making over its approval. In this work it was not possible to obtain similar single ES valuation studies due to the different spatial and temporal context of the existent available literature.

However the robustness of the benefit transfer method of meta-analysis of the ES valuation study used in this work compared different studies of the same environmental resource valuation improving its credibility. By the other hand, the meta-analysis share the same geographical region as the forests of EIA sample case studies, using two valuation methods from its original case studies, the travel cost method in resemblance to the majority of cultural services valuation studies (Jónsson and Davíðsdóttir, 2016), a method that also can be used to bolster contingent valuation studies on cultural services (Cook et al., 2016), and the contingent valuation usually used on cases where limited or no observed behaviour exists such as the cultural services here considered (Cook et al., 2016), being the last one considerably susceptible of hypothetical bias variation across different countries. This must be taken in consideration given the variety of the original study cases of the meta-analysis belong to a group of different countries from which Portugal is not included.

In this work it was considered that the ES establish the connection between the environmental resources and the human well-being in two ways: through the contribution for the generation of incomes and well-being, and though the prevention of damages that causes cost for the society as it stated by DEFRA (DEFRA, 2007). That said it makes sense to place a monetary value on those ES since we refer to incomes and costs that usually are translated to monetary units, but this is a disagreement point between several actors, either supporting it or opposing it. DEFRA (2007) refers that the valuation of the environmental impact (from which the ES are included) allows to include it in monetary analysis of cost-benefit and thus simplify its comparison with other monetizing costs and benefits (DEFRA, 2007), conclusion shared by Honrado *et al*. 2013 in his study (Honrado et al., 2013). Its policy regarding the valuation its clear, this is a priority, but in case of not being possible it recommends that the impacts must be presented in quantitative terms and in last resource, in if not possible to apply, resort to an qualitative evaluation of the potential impacts (DEFRA, 2007), being this last one common among the analysed EIA cases in this work. For a better understanding of the concept of quantifying an environmental impact, it may be referred the case of carbon sequestration by part of a forest affected by a given EIA project, where the quantity of carbon that the forest is able to accumulate, given a certain weight in carbon per time unit, will be reduced or null depending of the forest's destiny during the implementation of the project (DEFRA, 2007). Farley (2012) on the other hand defends the non-valuation in a preferential way, stating that attributing monetary values is not enough to assure choices (Farley, 2012). In the same study it is referred that in the critical ES case such as the purification water service (defined in the group of water conditions, in the regulation and maintenance section by CICES) where being critic comprehends a fierce competition, enough for at least some individuals who are benefit from it, cannot satisfy their basic needs and thus occurring the surpass the physiological limits (Farley, 2012). This theory counterpoints the objectives imposed by this work, which includes the principle followed by this work that any attributed monetary value to an environmental resource is always useful for decision making, being that as in Costanza *et al.* 1997 not having a monetary valued attributed is the same as consider an environmental resource to have an absolute zero value (Costanza et al., 1997).

As previously stated in this work the valuation of the environmental resources approach centres in marginal changes occurred at quality and quantity level of the ES considering as basis the baseline option, which means the current ES conditions and if possible the estimates for the future of that scenario involving the ES. This is then a common process in cost-benefit analysis where those changes in the baseline option scenario are counterpoised to other options (DEFRA, 2007; Honrado et al., 2013) and that is compatible with the structure of the EIA, where different project alternatives are presented together with the absence of any project, the baseline option (2014). It is then a matter of a choice to facilitate the integration of the ES valuation approach in a pre-existent structure (original scenario without project) and also to facilitate analysis cost-benefit for the decision makers.

It is important to emphasize that opposing to Honrado *et al.* 2013 that considers important to integrate four types of ES: support, provision, regulating and cultural (Honrado et al., 2013), this work follows the hierarchical structure of the Haines-Young, R. and Potschin, M. cascade model adopted by the CICES, accounting only the final ES, that provide the benefits directly for the humans, in this case, excluding the support services considered by that study.

The benefit transfer method here referred is appointed as the best solution to avoid the conduction of specific studies for each EIA project, nevertheless UKNEA (2011) states that this method it is not the perfect approach due to its biases both in temporal and cultural levels (UKNEA, 2011). In fact the temporal context of the CESVS does not match the case samples data, were the year 2005 scenario with estimations for the year 2050 is not similar to the 2016/2017 years of the EIA cases realization date, moreover it did not even included any case study from any region of Portugal, although it used a European countries that share the same Mediterranean habitat, nevertheless both countries have different geographic context, thus different cultures which may weight on the socioeconomic conditions and preferences from the population of each different country/region.

A good example of the current CICES framework application is the Belgian national ES classification, the CICES-Be, where this framework was chosen for being one of the most detailed ES classification systems available (Mononen et al., 2016; Turkelboom et al., 2013). Particularly, CICES is composed in hierarchical order ES categories from the wider to the more specific by Section, Division, Group and Class, and CICES-Be has the same structure although it adds sub-classes to the last hierarchic component. If the CICES-Be framework was adopted to this work, the results regarding the ES classification presented in Table 7 would had a different outcome, starting with the three case samples subjected to the application of the benefit transfer valuation method. They were chosen due to their shared ES group, namely the physical use of land-/seascapes, belonging to the division physical and intellectual interactions according to CICES, however in CICES-Be this division is divided in to different groups: natural environment suitable for outdoor activities and natural surroundings of built-up areas. Although the three case samples belong to the same division, the natural environment suitable for outdoor activities, the class and subclass would not be homogeneous. Firstly the three cases can be separated by the public or private access to the implemented area, since case number 1 would be classified into the class area for non-excludable outdoor activities due to the reported openly visiting from tourists inside the implemented area, in the other hand, both project number 4 and 13 would be classified into the class area for excludable outdoor activities due to the controlled hunting zone and tight terrain area respectively. Eventually those two case samples would be discriminated within the each ES sub-class, being case number 4 due to its hunting benefits, classified as area for land-consuming productive activities and case number 13 due to its relaxation benefits, classified as area for land consuming recreation. Regarding the case number 1, due to its benefits from walking in the project comprised area, it is considered to integrate the sub-category landscape and outdoor recreation. The outcome of adoption the CICES-Be framework on the considered case studies for the application of the valuation methods would be the attribution of different ES subclass for each case, having two different groups to be considered comparing with previously CICES classification. That said, the higher specification of the classification of the CICES-Be in comparison with CICES, is notorious in the previous example, showing the adaptation to the Belgium national context, but at the same time, allowing a wider application, in a different situation for the three different EIA sample cases considered here. Of course this explicitly more specific approach is intrinsically bond to a higher complexity, already referred in this work as a disadvantage for its standard use, although in the Belgian context for instance, the division of the CICES-Be ES group natural environment suitable for outdoor activities in two different classes, the area for non-excludable outdoor activities and the area for excludable outdoor activities respectively, as some categories of this last class are rapidly expanding in this country, and as excludability controls to a large extent, how many people can benefit from those ES (Mononen et al., 2016; Turkelboom et al., 2013). In this particular case, this framework was adapted to fulfil the needs of that country and simultaneously to respect the international standards, which demonstrates that this ES evaluation tool might be refined so it could improve its application both at national as EU level, and even as international standard. Yet this necessity of change also means that this system it is still not perfect and so it can suffer from more changes at base model level and thus do not require any changes in its specific application in certain countries/regions.

5. CONCLUSIONS

The realization of this dissertation has allowed the accomplishment of the proposed primary objective, successfully demonstrating the practical application of the Environmental Resources Valuation in EIA projects from distinct intervention areas between EU state members, and as previously stated, focusing the attention on the Portuguese situation. Although this positive outcome the many challenges encountered during the realization of this work suggests that the practice of this approach may yet be far from being implemented. This becomes more evident when the limitations associated to each one of the main subjects here addressed are pointed out.

The bibliographic review of the environmental resources valuation have demonstrated that two different elements, the ES frameworks and the economic valuation methods can be combined namely to define and categorize the goods and services, and to obtain monetary values from that resources. The economic valuation methods are well defined and commonly accepted at international level, being capable of providing a good variety of different methods, although it lacks mainly on the potential valuation of non-marketed goods and services. As observed in this work a vast majority of those goods and services constitute ES, the same ones that establish the link between the environmental resources and the human wellbeing. So it is particularly interesting to adopt an environmental resources valuation system, combining ES framework that includes the definition and classification of ES and other abiotic factors that influence them, with a single or set of different valuation methods. Although the relatively simplistic concept of the combination of these two different elements, the practical cases are at an early stage, as the ES frameworks in contrast with the valuation methods, not yet so much consensual requiring more research data to be recognized.

After analysing the Portuguese EIA sample cases, the very inexistence of any kind of integrated environmental resources valuation system was a strong indicator that this is a pioneer measure of the current situation regarding these procedures at national level. It was also impossible to conclude if this were a common scenario between all the remaining EU state members, or just Portugal, due to the already stated individual policy regarding lack of permanent public accessible database containing EIA documents from each state member. Anyway it was observable in EIA sample cases that there is already an assessment of ES without any kind of framework structure, as it was already predicted.

Finally firstly a theoretical environmental resources valuation approach was proposed, and then a practical example involving the valuation of the physical use of land-/seascapes, including in the cultural services already present, demonstrated the possibility of including this system in an integrated way in future EIA projects, but also the capability of apply this procedures on some ES of already existent ones. Although the presented environmental resources valuation in this work only applies to the current situation of the implementation area of a given project in its absence, not providing an estimate to the assessment on the changes in affected ES state, nor mitigation measures, it achieves its goal of providing the stakeholders with important information about the benefits that those resources may provide. Nevertheless the challenges of the integration of this system aggregate with the already issues regarding the ES frameworks and the economic methodologies, being the economic and time consuming with the lack of consensus about the adoption of an ES framework the main limitations for the limitation of this system implementation.

6. Recommendations

A continuous research on the field of ES towards their precise definition, classification and valuation is a key issue, to improve existing, or create more commonly accepted ES frameworks, as it has been for the previous ones from MEA to CICES. Moreover the more studies involving this procedures, the less redundancy issues the environmental resources system will have, due to its preferred valuation method, the benefit transfer, which always benefits from a larger amount of specific site studies.

The application of environmental resources valuation systems such as the one presented in this work in EIA projects may be potentiated with its integration at EU level through its implementation in each state member via EIA Directives.

Additionally the heterogeneity observable in part of projects categories subjected to EIA due to the EU environmental directive's flexibility regarding the local project categorization standards by each member state, which could be solved through an integrated general standardization by a future EU directive, providing a simpler EIA data analysis within the EU. This measure may be potentiated by additional integration in that directive, or by volunteer action of each EU member state to provide the documents regarding the EIA conducted at local level in electronic format and in a permanent database facilitating the access to any European citizen and mainly, promoting the EIA analysis by researchers between each member state.

7. References

(1985). *Council Directive of 27 June 1985 on the assessment of the effects of certain public and private projects on the environment (85/337/EEC)*. European Comission. Belgium.

(1997). *Council Directive 97/1 1 /EC of 3 March 1997 amending Directive 85/337/EEC on the assessment of the effects of certain public and private projects on the environment*. European Comission. Belgium.

(2003). *Directive 2003/35/EC of the European Parliament and the Council of 26 May 2003 providing for public participation in respect of the drawing up of certain plans and programmes relating to the environment and amending with regard to public participation and access to justice Council Directives 85/337/EEC and 96/61/EC*. European Comission. Belgium.

(2009). *Directive 2009/31/EC of the European Parliament and the Council of 23 April 2009 on the geological storage of carbon dioxide and amending Council Directive 85/337/EEC, European Parliament and Council Directives 2000/60/EC, 2001/80/EC, 2004/35/EC, 2006/12/EC, 2008/1/EC and Regulation (EC) No 1013/2006*. European Comission. France.

(2012). *Decreto Lei no 56/2012 de 12 de março do Ministério da Agricultura, do Mar, do Ambiente e do Ordenamento do Território*. Ministério da Agricultura, do Mar, do Ambiente e do Ordenamento do Território. Portugal.

(2012). *Directive 2011/92/EU of the European Parliament and the Council of 13 December 2011 on the assessment of the effects of certain public and private projects on the environment*. France.

(2013). *Decreto Lei no 151-B/2013 de 31 de outubro do Ministério da Agricultura, do Mar, do Ambiente e do Ordenamento do Território*. Portugal.

(2013). *Ley 21/2013 de 9 de diciembre de evaluación ambiental*. Spain.

(2014). *Directive 2014/52/EU of the European Parliament and the Council of 16 April 2014 amending Directive 2011/92/EU on the assessment of the effects of certain public and private projects on the environment* European Parliament and of the Council. France.

Adhikari, K. and Hartemink, A.E. (2016). Linking soils to ecosystem services - A global review. *Geoderma*. 262: 101-111.

Arcadis Belgium (2011). *Recognizing Natura 2000 Benefits and Demonstrating the Economic Benefits of Conservation Measures*. Available on http://ec.europa.eu/environment/nature/natura2000/financing/docs/Recognizing_Natura 2000_benefits.pdf

Barrio, M. and Loureiro, M.L. (2010). A meta-analysis of contingent valuation forest studies. *Ecological Economics*. 69: 1023-1030.

Beaumont, N.J., Austen, M.C., Atkins, J.P., Burdon, D., Degraer, S., Dentinho, T.P., Derous, S., Holm, P., Horton, T., van Ierland, E., Marboe, A.H., Starkey, D.J., Townsend, M. and Zarzycki, T. (2007). Identification, definition and quantification of goods and services provided by marine biodiversity: Implications for the ecosystem approach. *Marine Pollution Bulletin*. 54: 253-265.

Biodiversity Information System for Europe, 2017. *Ecosystem services categories*. <http://biodiversity.europa.eu/maes/ecosystem-services-categories-in-millennium-ecosystem-assessment-ma-the-economics-of-ecosystem-and-biodiversity-teeb-and-common-international-classification-of-ecosystem-services-cices> (accessed 27-01-2017.2017).

Blicharska, M., Smithers, R.J., Hedblom, M., Hedenås, H., Mikusiński, G., Pedersen, E., Sandström, P. and Svensson, J. (2017). Shades of grey challenge practical application of the cultural ecosystem services concept. *Ecosystem Services*. 23: 55-70.

Boerema, A., Rebelo, A.J., Bodi, M.B., Esler, K.J. and Meire, P. (2016). Are ecosystem services adequately quantified? *Journal of Applied Ecology*. 54: 358-370.

Boyd, J. and Banzhaf, S. (2007). What are ecosystem services? The need for standardized environmental accounting units. *Ecological Economics*. 63: 616-626.

Brander, L.M., Florax, R.J.G.M. and Vermaat, J.E. (2006). The Empirics of Wetland Valuation: A Comprehensive Summary and a Meta-Analysis of the Literature. *Environmental and Resource Economics*. 33: 223-250.

Broekx, S., Liekens, I., Peelaerts, W., De Nocker, L., Landuyt, D., Staes, J., Meire, P., Schaafsma, M., Van Reeth, W., Van den Kerckhove, O. and Cerulus, T. (2013). A web application to support the quantification and valuation of ecosystem services. *Environmental Impact Assessment Review*. 40: 65-74.

Brunner, S.H., Huber, R. and Grêt-Regamey, A. (2016). A backcasting approach for matching regional ecosystem services supply and demand. *Environmental Modelling & Software*. 75: 439-458.

Burkhard, B., Kroll, F., Nedkov, S. and Müller, F. (2012). Mapping ecosystem service supply, demand and budgets. *Ecological Indicators*. 21: 17-29.

Chee, Y.E. (2004). An ecological perspective on the valuation of ecosystem services. *Biological Conservation*. 120: 549-565.

Chiabai, A., Travisi, C.M., Markandya, A., Ding, H. and Nunes, P.A.L.D. (2011). Economic Assessment of Forest Ecosystem Services Losses: Cost of Policy Inaction. *Environmental and Resource Economics*. 50: 405-445.

Cook, D., Davíðsdóttir, B. and Kristófersson, D.M. (2016). Energy projects in Iceland – Advancing the case for the use of economic valuation techniques to evaluate environmental impacts. *Energy Policy*. 94: 104-113.

Costanza, R., d'Arge, R., de Groot, R., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'Neill, R.V., Paruelo, J., Raskin, R.G., Sutton, P. and van den Belt, M. (1997). The Value of the World's Ecosystem Services and Natural Capital. *Nature*. 387: 253-260.

Costanza, R., de Groot, R., Sutton, P., van der Ploeg, S., Anderson, S.J., Kubiszewski, I., Farber, S. and Turner, R.K. (2014). Changes in the global value of ecosystem services. *Global Environmental Change*. 26: 152-158.

Crossman, N.D., Burkhard, B., Nedkov, S., Willemen, L., Petz, K., Palomo, I., Drakou, E.G., Martín-Lopez, B., McPhearson, T., Boyanova, K., Alkemade, R., Egoh, B., Dunbar, M.B. and Maes, J. (2013). A blueprint for mapping and modelling ecosystem services. *Ecosystem Services*. 4: 4-14.

Damigos, D. (2006). An overview of environmental valuation methods for the mining industry. *Journal of Cleaner Production*. 14: 234-247.

Damigos, D., Menegaki, M. and Kaliampakos, D. (2016). Monetizing the social benefits of landfill mining: Evidence from a Contingent Valuation survey in a rural area in Greece. *Waste Management*. 51: 119-129.

de Groot, R., Brander, L., van der Ploeg, S., Costanza, R., Bernard, F., Braat, L., Christie, M., Crossman, N., Ghermandi, A., Hein, L., Hussain, S., Kumar, P., McVittie, A., Portela, R., Rodriguez, L.C., ten Brink, P. and van Beukering, P. (2012). Global estimates of the value of ecosystems and their services in monetary units. *Ecosystem Services*. 1: 50-61.

Department for Environment Food and Rural Affairs (2007). *An introductory guide to valuing ecosystem services*. 19/03/2017. Available on http://ec.europa.eu/environment/nature/biodiversity/economics/pdf/valuing_ecosystems.pdf

Ding, H., Chiabai, A., Silvestri, S. and Nunes, P.A.L.D. (2016). Valuing climate change impacts on European forest ecosystems. *Ecosystem Services*. 18: 141-153.

Economics for the Environment Consultancy Great Britain (1998). *Review of Technical Guidance on Environmental Appraisal: A Report by EFTEC (Economics for the Environment Consultancy)*), United Kingdom: Department of the Environment, Transport and the Regions.

Egli, T., Bolliger, J. and Kienast, F. (2017). Evaluating ecosystem service trade-offs with wind electricity production in Switzerland. *Renewable and Sustainable Energy Reviews*. 67: 863-875.

European Comission (2011). *The EU Biodiversity Strategy to 2020*. 25/11/2016. Available on http://ec.europa.eu/environment/nature/info/pubs/docs/brochures/2020%20Biod%20brochure%20final%20lowres.pdf

European Comission (2013). *Mapping and Assessment of Ecosystems and their Services*. 19/01/2017. Available on http://ec.europa.eu/environment/nature/knowledge/ecosystem_assessment/pdf/MAESWorkingPaper2013.pdf

European Environment Agency (2010). *Scaling up ecosystem benefits - assessing large-scale ecosystem services with primary data.* 14/12/2016. Available on https://www.google.pt/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0ahUKEwjExNmB5M7UAhWH8RQKHVGBCB4QFggrMAA&url=https%3A%2F%2Fwww.eea.europa.eu%2Fpublications%2Fscaling-up-ecosystem-benefits-a%2Fdownload&usg=AFQjCNG-KF3ODFrusI0NdJqxHGgoRymiow&cad=rja

Everard, M. (2016). Community-based groundwater and ecosystem restoration in semi-arid north Rajasthan (2): Reviving cultural meaning and value. *Ecosystem Services*. 18: 33-44.

Fagerholm, N., Torralba, M., Burgess, P.J. and Plieninger, T. (2016). A systematic map of ecosystem services assessments around European agroforestry. *Ecological Indicators*. 62: 47-65.

Farber, S.C., Costanza, R. and Wilson, M.A. (2002). Economic and ecological concepts for valuing ecosystem services. *Ecological Economics*. 41: 375-392.

Farhad, S., Gual, M.A. and Ruiz-Ballesteros, E. (2015). Linking governance and ecosystem services: The case of Isla Mayor (Andalusia, Spain). *Land Use Policy*. 46: 91-102.

Farley, J. (2012). Ecosystem services: The economics debate. *Ecosystem Services*. 1: 40-49.

Fisher, B., Turner, R.K. and Morling, P. (2009). Defining and classifying ecosystem services for decision making. *Ecological Economics*. 68: 643-653.

Foley, J.A., DeFries, R., Asner, G.P., Barford, C., Bonan, G., Carpenter, S.R., Chapin, F.S., Coe, M.T., Daily, G.C., Gibbs, H.K., Helkowski, J.H., Holloway, T., Howard, E.A., Kucharik, C.J., Monfreda, C., Patz, J.A., Prentice, I.C., Ramankutty, N. and Snyder, P.K. (2005). Global Consequences of Land Use. *Science*. 309: 570-574.

Friedrich, L.A., Dodds, W., Philippe, M., Glegg, G., Fletcher, S. and Bailly, D. (2015). *Improving stakeholder engagement in marine management through ecosystem service assessment. A Guide for Practitioners Based on Experience from the VALMER Project.* 25/03/2017. Available on http://www.valmer.eu/wp-content/uploads/2015/03/WP4-3-English.pdf

Ghermandi, A., van den Bergh, J.C.J.M., Brander, L.M., de Groot, H.L.F. and Nunes, P.A.L.D. (2010). Values of natural and human-made wetlands: A meta-analysis. *Water Resources Research*. 46: n/a-n/a.

Haines-Young, R. and Potschin, M. (2013). *Common International Classification of Ecosystem Services (CICES): Consultation on Version 4, August-December 2012*. 15/10/2016. Available on https://cices.eu/content/uploads/sites/8/2012/07/CICES-V43_Revised-Final_Report_29012013.pdf

Halvorson, W.L. and Davis, G.E. (1996). *Science and ecosystem management in the national parks*), Tucson: University of Arizona Press.

Hammitt, J.K. (2000). Valuing Mortality Risk: Theory and Practice. *Environmental Science and Technology*. 34: 1396-1400.

Häyhä, T. and Franzese, P.P. (2014). Ecosystem services assessment: A review under an ecological-economic and systems perspective. *Ecological Modelling*. 289: 124-132.

Heink, U., Hauck, J., Jax, K. and Sukopp, U. (2016). Requirements for the selection of ecosystem service indicators – The case of MAES indicators. *Ecological Indicators*. 61: 18-26.

Her Majesty's Treasury (2011). *The Green book: Appraisal and Evaluation in Central Government*. 10/02/2017. Available on https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/220541/green_book_complete.pdf

Honrado, J.P., Vieira, C., Soares, C., Monteiro, M.B., Marcos, B., Pereira, H.M. and Partidário, M.R. (2013). Can we infer about ecosystem services from EIA and SEA practice? A framework for analysis and examples from Portugal. *Environmental Impact Assessment Review*. 40: 14-24.

Jónsson, J.Ö.G. and Davíðsdóttir, B. (2016). Classification and valuation of soil ecosystem services. *Agricultural Systems*. 145: 24-38.

Kienast, F., Bolliger, J., Potschin, M., de Groot, R.S., Verburg, P.H., Heller, I., Wascher, D. and Haines-Young, R. (2009). Assessing Landscape Functions with Broad-Scale Environmental Data: Insights Gained from a Prototype Development for Europe. *Environmental Management*. 44: 1099-1120.

Koundouri, P., Ker Rault, P., Pergamalis, V., Skianis, V. and Souliotis, I. (2016). Development of an integrated methodology for the sustainable environmental and socio-economic management of river ecosystems. *Science of The Total Environment*. 540: 90-100.

La Notte, A., D'Amato, D., Mäkinen, H., Paracchini, M.L., Liquete, C., Egoh, B., Geneletti, D. and Crossman, N.D. (2017). Ecosystem services classification: A systems ecology perspective of the cascade framework. *Ecological Indicators*. 74: 392-402.

La Rosa, D., Spyra, M. and Inostroza, L. (2016). Indicators of Cultural Ecosystem Services for urban planning: A review. *Ecological Indicators*. 61: 74-89.

Landers, D. and Nahlik, A.M. (2013). *Final ecosystem goods and services classification system (FEGS-CS)*. 23/02/2017. Available on https://cfpub.epa.gov/si/si_public_file_download.cfm?p_download_id=515244

Lee, H. and Lautenbach, S. (2016). A quantitative review of relationships between ecosystem services. *Ecological Indicators*. 66: 340-351.

Lemasson, A.J., Fletcher, S., Hall-Spencer, J.M. and Knights, A.M. (2017). Linking the biological impacts of ocean acidification on oysters to changes in ecosystem services: A review. *Journal of Experimental Marine Biology and Ecology*. 492: 49-62.

Liquete, C., Piroddi, C., Drakou, E.G., Gurney, L., Katsanevakis, S., Charef, A. and Egoh, B. (2013). Current Status and Future Prospects for the Assessment of Marine and Coastal Ecosystem Services: A Systematic Review. *PLOS ONE*. 8: e67737.

Maczka, K., Matczak, P., Pietrzyk-Kaszyńska, A., Rechciński, M., Olszańska, A., Cent, J. and Grodzińska-Jurczak, M. (2016). Application of the ecosystem services concept in environmental policy—A systematic empirical analysis of national level policy documents in Poland. *Ecological Economics*. 128: 169-176.

Maes, J., Liquete, C., Teller, A., Erhard, M., Paracchini, M.L., Barredo, J.I., Grizzetti, B., Cardoso, A., Somma, F., Petersen, J.-E., Meiner, A., Gelabert, E.R., Zal, N., Kristensen, P., Bastrup-Birk, A., Biala, K., Piroddi, C., Egoh, B., Degeorges, P., Fiorina, C., Santos-Martín, F., Naruševičius, V., Verboven, J., Pereira, H.M., Bengtsson, J., Gocheva, K., Marta-Pedroso, C., Snäll, T., Estreguil, C., San-Miguel-Ayanz, J., Pérez-Soba, M., Grêt-Regamey, A., Lillebø, A.I., Malak, D.A., Condé, S., Moen, J., Czúcz, B., Drakou, E.G., Zulian, G. and Lavalle, C. (2016). An indicator framework for assessing ecosystem services in support of the EU Biodiversity Strategy to 2020. *Ecosystem Services*. 17: 14-23.

Malinga, R., Gordon, L.J., Jewitt, G. and Lindborg, R. (2015). Mapping ecosystem services across scales and continents – A review. *Ecosystem Services*. 13: 57-63.

Martín-López, B., Gómez-Baggethun, E., García-Llorente, M. and Montes, C. (2014). Trade-offs across value-domains in ecosystem services assessment. *Ecological Indicators*. 37: 220-228.

Martinez-Harms, M.J. and Balvanera, P. (2012). Methods for mapping ecosystem service supply: a review. *International journal of biodiversity science, ecosystem services & management*. 8: 17–25.

Mascarenhas, A., Ramos, T.B., Haase, D. and Santos, R. (2016). Participatory selection of ecosystem services for spatial planning: Insights from the Lisbon Metropolitan Area, Portugal. *Ecosystem Services*. 18: 87-99.

Millennium Ecosystem Assessment (2005). *Ecosystems and Human Well-Being: Synthesis*. 04/12/2016. Available on http://www.millenniumassessment.org/documents/document.356.aspx.pdf

Millington, K. (2007). The exchange rates of the euro vs. other main currencies and their impact on EU tourism. 05/12/2016. Available on http://www.europarl.europa.eu/RegData/etudes/note/join/2007/379231/IPOL-TRAN_NT(2007)379231_EN.pdf

Mononen, L., Auvinen, A.P., Ahokumpu, A.L., Rönkä, M., Aarras, N., Tolvanen, H., Kamppinen, M., Viirret, E., Kumpula, T. and Vihervaara, P. (2016). National ecosystem service indicators: Measures of social–ecological sustainability. *Ecological Indicators*. 61: 27-37.

Naturkapital Deutshland - The Economics of Ecosystems and Biodiversity DE (2014). *Naturkapital und klimapolitik – synergienund konflikte*. 04/02/2017. Available on https://www.bfn.de/fileadmin/BfN/oekonomie/Dokumente/teeb_de_klimabericht_langfassung.pdf

Ojea, E., Nunes, P.A.L.D. and Loureiro, M.L. (2010). Mapping Biodiversity Indicators and Assessing Biodiversity Values in Global Forests. *Environmental and Resource Economics*. 47: 329-347.

Pérez-Blanco, C.D., Standardi, G., Mysiak, J., Parrado, R. and Gutiérrez-Martín, C. (2016). Incremental water charging in agriculture. A case study of the Regione Emilia Romagna in Italy. *Environmental Modelling & Software*. 78: 202-215.

Pietrzyk-Kaszyńska, A., Czepkiewicz, M. and Kronenberg, J. (2017). Eliciting non-monetary values of formal and informal urban green spaces using public participation GIS. *Landscape and Urban Planning*. 160: 85-95.

Plieninger, T., Dijks, S., Oteros-Rozas, E. and Bieling, C. (2013). Assessing, mapping, and quantifying cultural ecosystem services at community level. *Land Use Policy*. 33: 118-129.

Pope, K.L., Pegg, M.A., Cole, N.W., Siddons, S.F., Fedele, A.D., Harmon, B.S., Ruskamp, R.L., Turner, D.R. and Uerling, C.C. (2016). Fishing for ecosystem services. *Journal of Environmental Management*. 183: 408-417.

Quyen, N.T.K., Berg, H., Gallardo, W. and Da, C.T. (2017). Stakeholders' perceptions of ecosystem services and Pangasius catfish farming development along the Hau River in the Mekong Delta, Vietnam. *Ecosystem Services*. 25: 2-14.

Raffaelli, D.F., C. (2010). *Ecosystem Ecology: A New Synthesis*.(1st edition), Cambridge: Cambridge University Press.

Ready, R. and Navrud, S. (2006). International benefit transfer: Methods and validity tests. *Ecological Economics*. 60: 429-434.

Rounsevell, M.D.A., Pedroli, B., Erb, K.-H., Gramberger, M., Busck, A.G., Haberl, H., Kristensen, S., Kuemmerle, T., Lavorel, S., Lindner, M., Lotze-Campen, H., Metzger, M.J., Murray-Rust, D., Popp, A., Pérez-Soba, M., Reenberg, A., Vadineanu, A., Verburg, P.H. and Wolfslehner, B. (2012). Challenges for land system science. *Land Use Policy*. 29: 899-910.

Saarikoski, H., Mustajoki, J., Barton, D.N., Geneletti, D., Langemeyer, J., Gomez-Baggethun, E., Marttunen, M., Antunes, P., Keune, H. and Santos, R. (2016). Multi-Criteria Decision Analysis and Cost-Benefit Analysis: Comparing alternative frameworks for integrated valuation of ecosystem services. *Ecosystem Services*. 22: 238-249.

Santos, J.M.L. (2007). Transferring Landscape Values: How And How Accurately? in: Navrud, S., Ready, R. (Eds.). Environmental Value Transfer: Issues and Methods. Springer Netherlands. Dordrecht. pp. 45-75.

Schwilch, G., Bernet, L., Fleskens, L., Giannakis, E., Leventon, J., Marañón, T., Mills, J., Short, C., Stolte, J., van Delden, H. and Verzandvoort, S. (2016). Operationalizing ecosystem services for the mitigation of soil threats: A proposed framework. *Ecological Indicators*. 67: 586-597.

Sen, A., Harwood, A.R., Bateman, I.J., Munday, P., Crowe, A., Brander, L., Raychaudhuri, J., Lovett, A.A., Foden, J. and Provins, A. (2014). Economic Assessment of the

Recreational Value of Ecosystems: Methodological Development and National and Local Application. *Environmental and Resource Economics*. 57: 233-249.

Seppelt, R., Dormann, C.F., Eppink, F.V., Lautenbach, S. and Schmidt, S. (2011). A quantitative review of ecosystem service studies: approaches, shortcomings and the road ahead. *Journal of Applied Ecology*. 42: 630-636.

Shrestha, R.K. and Loomis, J.B. (2001). Testing a meta-analysis model for benefit transfer in international outdoor recreation. *Ecological Economics*. 39: 67-83.

Swetnam, R.D., Harrison-Curran, S.K. and Smith, G.R. (2016). Quantifying visual landscape quality in rural Wales: A GIS-enabled method for extensive monitoring of a valued cultural ecosystem service. *Ecosystem Services*.

Tenerelli, P., Demšar, U. and Luque, S. (2016). Crowdsourcing indicators for cultural ecosystem services: A geographically weighted approach for mountain landscapes. *Ecological Indicators*. 64: 237-248.

The Economics of Ecosystems and Biodiversity (2010). *The Economics of Ecosystems and Biodiversity: Mainstreaming the Economics of Nature: A Synthesis of the Approach, Conclusions and Recommendations of TEEB*. 11/01/2017. Available on http://doc.teebweb.org/wp-content/uploads/Study%20and%20Reports/Reports/Synthesis%20report/TEEB%20Synthesis%20Report%202010.pdf

Tietenberg, T. and Lewis, L. (2011). *Environmental & Natural Resources Economics*.(9th edition), New Jersey: Pearson Education, Inc.

Turkelboom, F., Raquez, P., Dufrêne, M., Raes, L., Simoens, I., Jacobs, S., Stevens, M., De Vreese, R., Panis, J.A.E., Hermy, M., Thoonen, M., Liekens, I., Fontaine, C., Dendoncker, N., Biest, K.v.d., Casaer, J., Heyrman, H., Meiresonne, L. and Keune, H. (2013). *Ecosystem Services*.(1st edition), Boston: Elsevier.

Turner, B.L., Lambin, E.F. and Reenberg, A. (2007). The Emergence of Land Change Science for Global Environmental Change and Sustainability. *Proceedings of the National Academy of Sciences of the United States of America (PNAS)*. 104: 20666-20671.

Turner, K.G., Anderson, S., Gonzales-Chang, M., Costanza, R., Courville, S., Dalgaard, T., Dominati, E., Kubiszewski, I., Ogilvy, S., Porfirio, L., Ratna, N., Sandhu, H., Sutton, P.C., Svenning, J.-C., Turner, G.M., Varennes, Y.-D., Voinov, A. and Wratten, S. (2016). A review of methods, data, and models to assess changes in the value of ecosystem services from land degradation and restoration. *Ecological Modelling*. 319: 190-207.

Ungaro, F., Häfner, K., Zasada, I. and Piorr, A. (2016). Mapping cultural ecosystem services: Connecting visual landscape quality to cost estimations for enhanced services provision. *Land Use Policy*. 54: 399-412.

United Kingdom National Ecosystem Assessment (2011). *UK National Ecosystem Assessment: Technical Report*. 07/10/2016. Available on http://uknea.unep-wcmc.org/LinkClick.aspx?fileticket=m%2BvhAV3c9uk%3D&tabid=82

United Kingdom National Ecosystem Assessment (2014). *The UK National Ecosystem Assessment: Synthesis of the Key Findings*. 17/09/2016. Available on http://uknea.unep-wcmc.org/LinkClick.aspx?fileticket=5L6%2fu%2b%2frKKA%3d&tabid=82

Verburg, P.H., Erb, K.-H., Mertz, O. and Espindola, G. (2013). Land System Science: between global challenges and local realities. *Current Opinion in Environmental Sustainability*. 5: 433-437.

Villa, F., Bagstad, K.J., Voigt, B., Johnson, G.W., Portela, R., Honzák, M. and Batker, D. (2014). A Methodology for Adaptable and Robust Ecosystem Services Assessment. *PLOS ONE*. 9: e91001.